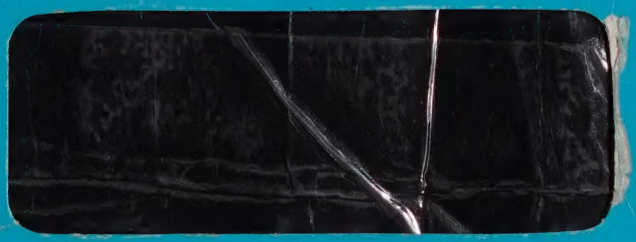
Operating Instructions



GOULD

GOULD BRUSH

MANUAL PART NO.
15-806325-00

BRUSH 222 RECORDER
ALL MODELS

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3631 Perkins Avenue-Cleveland, Ohio 44114

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SECTION I

GENERAL INFORMATION

1.1 SCOPE

This technical manual contains specifications and instructions for operation and maintenance of the Brush 222 Recorder. It also contains description of, and procedures for installation, inspection, troubleshooting, repair and servicing of the 222 and its accessories.

1.2 INTRODUCTION

The solid-state Brush 222 is an internally powered, accurate, rugged, lightweight, two channel recorder for use anywhere. Traces are crisp, clear and smudge-free produced by a pressurized ink system. A disposable ink cartridge holds a one year supply of ink and can be cleanly replaced in minutes. Whenever the power is off or low, or the chart paper runs out, the writing system stops and ink is withdrawn from the pen tip.

This completely self-contained portable recorder has two 40mm analog channels and two event channels. Other features include built-in preamplifiers, electronic limiters, a measurement range from one millivolt/division to 500 volts full scale, linearity of 99.5% enforced by the exclusive Brush frictionless pen position servo system, frequency response above 30 Hz full scale, and six chart speeds. An external d-c chart drive mode permits variable chart speeds over the full range from 1 mm/sec to 50 mm/sec.

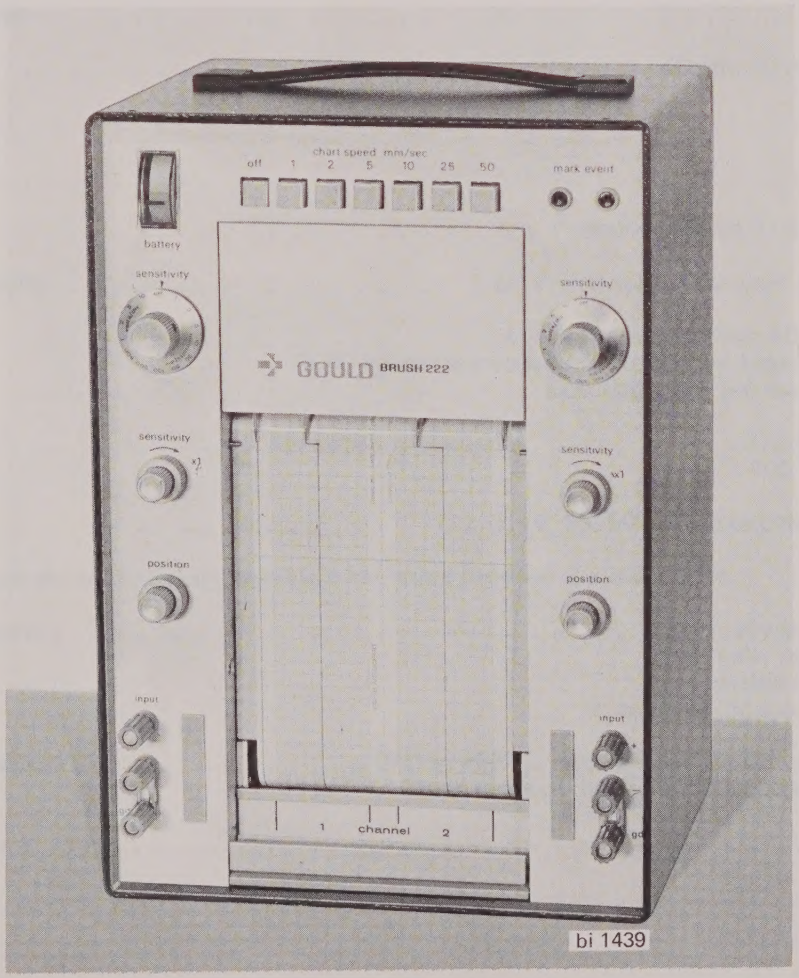


FIGURE 1-1 BRUSH 222 BATTERY OPERATED RECORDER

Since both inputs are isolated from each other, from chassis and from the output, the 222 can be used with all types of signal sources--grounded, floating, or driven off-ground--without affecting accuracy or creating system noise.

The internal battery supply has a total operating life of up to 6,000 hours when recycled by the recorder's built-in charger. The charger is activated simply by plugging its power input module into an external a-c or d-c source (depending upon the model selected). The batteries allow continuous operation for up to 12 hours and can be completely recharged in 16 hours. To avoid recording of inaccurate data, an automatic ink shut-off is actuated if the battery voltage falls below a predetermined level.

"Line assisted" operation allows unrestricted recording time. This is accomplished by powering the charger from an external source at all times, so as to keep a full charge on the batteries.

1.3 SPECIFICATIONS

This paragraph lists the specifications and data pertinent to the Brush 222 Recorder.

a. General

Number of Channels . . . . . 2 Analog, 2 Event

Channel Width . . . . . 40mm, 50 divisions per channel

Trace Presentation . . . . . Rectilinear

Trace Width . . . . . 0.01 inch nominal

Writing Method . . . . . Pressurized fluid (U.S. Patent 3,054,109)

Writing Fluid Capacity . . . . . 1 oz; sufficient for one year of normal recording

Chart Description . . . . . 4.3 inches wide——two 40mm grids graduated in 50 divisions across span. Graduated 1mm increments on time axis. Right and left event marker channels

Chart Capacity . . . . . 275 feet — high contrast
400 feet — reproducible

Chart Speeds . . . . . 1, 2, 5, 10, 25, 50 millimeters per second and STOP

NOTE: Chart speeds are continuously variable when using External d-c chart drive.

Chart Speed Inaccuracy . . . . . Internally controlled, ±2% max
externally controlled, ±3% max
(Adjustable to within ±0.5% for any specific speed above 2mm/sec.)

Operating Temperature . . . . . 0° C to +55° C. Recorder will remain within specification over range of ±10° C from temperature at calibration

Storage Temperature . . . . . −40° C to +37° C

Weight . . . . . 26 pounds

b. Electrical

Sensitivity . . . . . 1 mv/div to 10 volts/div

Measurement Range . . . . . 1 millivolt per chart division to 500 volts d-c full scale (50 chart divisions)

Input Circuit . . . . . Differential, balanced-to-guard

Input Impedance . . . . . 10 megohms balanced, 5 megohms each terminal to guard

Signal Input

In-Phase Rejection . . . . . 80 dB at 60 Hz with maximum source unbalance of 10 kilohms (at 1mv/div. attenuator setting).

Maximum Signal Input . . . . . 500 volts d-c or peak a-c

Maximum Common Mode Voltage . . . . . a) 500 volts d-c or peak a-c at any attenuator setting between input terminals and case ground

b) 5,000 times the VOLTS/DIV sensitivity setting up to a maximum of 500 volts

ATTENUATOR SETTING	MAX. COMMON-MODE VOLTAGE
1 mV/div	5V d-c
2 mV/div	10V d-c
5 mV/div	25V d-c
10 mV/div	50V d-c
20 mV/div	100V d-c
all others	500V d-c

Non-Linearity . . . . . 0.5% full scale

Frequency Response . . . . . 50 div ±1 div d-c to 30 Hz
10 div ±1 div d-c to 10 Hz
3 dB down at 100 Hz

Stability (after 10 second warm-up and excluding paperdrift)*

Zero with respect to

Time . . . . . ±0.1 div for 8 hours

Temperature . . . . . ±0.1 div per °C, 25°C ±10°C

Gain with respect to

Time . . . . . ±0.1% per 8 hours

Temperature . . . . . ±0.05% per °C, 25°C ±10°C

*Battery potential of 11.7 vd-c (average battery voltage)

Charger Power Input

15-6325-00 . . . . . 115 volts ±10%, 50-400 Hz, 41VA
15-6325-01 . . . . . 230 volts ±10%, 50-400 Hz, 46VA
15-6325-02 . . . . . 12-33V d-c max; 1 amp max current

1.4 SUPPLIES AND ACCESSORIES

a. Supplies

Chart Paper

High-Contrast, Kromekote (275 feet) 1 mm time line	11-2923-32
Reproducible (400 feet)	11-2923-43
Analog Pen	11-2823-33
Extended Life Analog Pen	11-2823-34
Event Marker Pen	11-2873-20
Ink Cartridge (1 oz)	11-2730-01
Battery	281296
Pen Replacement Wrench (Multiple Splined)	1-120922-2
Pen Pressure Adjustment Wrench (Multiple Splined)	1-120922-18
Gram Gage (Pen Pressure)	240601-910
Band Replacement Tool	341409-915
Band Replacement Wrench (Multiple Splined)	1-120922-3
Band Replacement Wrench (Hex)	245218-5

b. Accessories

Starter Kit	11-6250-00

(Consists of)

Chart Paper (12 rolls)	11-2923-32
Gram Gage	240601-910
Pen Pressure Wrench	1-120922-18
Pen Replacement Wrench	1-120922-2
Dust Cover	465971

Replacement Kit	11-6251-00

(Consists of)

Chart Paper (12 rolls)	11-2923-32
Analog Pens (2)	11-2823-33
Event Marker Pens (2)	11-2873-20
Ink Cartridge (1 oz)	11-2730-01
Rack Mounting Kit	11-1202-08
Internal One-Second Timer	11-6101-41
Chart Takeup	11-6402-03

Interchannel Event Marker Kit 11-6221-01

Dust Cover 465971

Power Adapter Modules:

- For 115 volts a-c 782235
- For 230 volts a-c 782233
- For 12 to 33V d-c 782237

Cigarette Lighter Cable Assembly (Negative ground) 782339

Battery Charger 369500-43001

SECTION II

INSTALLATION

2.1 GENERAL

This section describes the inspection checks to be performed upon receipt of the Brush 222 and details power requirements and signal connections. In addition, this section describes and illustrates installation of the Chart Take-Up, Interchannel Event Marker, One-Second Timer, and Rack Mounting Kit.

2.2 INCOMING INSPECTION

Perform the following procedures before operating the recorder.

1. Visually inspect unit for damage that may have occurred during shipment. Refer to warranty sheet in case of damage.

2. Remove packing material and tape from recorder.

NOTE: Do not attempt to operate this equipment before completing Section III, Operation.

2.3 POWER REQUIREMENTS

Listed below are the voltage, frequency, and power requirements for the various Input Power Adapter Modules for the Brush 222 Recorder.

Model No. Charger Power Source

15-6325-00 – 115V a-c, ±10%, 50–400 Hz,41VA
15-6325-01 – 230V a-c, ±10%, 50–400 Hz,46VA
15-6325-02 – 12 to 33V d-c, 1.5 amp

The Brush 222 Recorder is always shipped and/or stored with two back panel fuses removed to prevent possible damage to battery. Before proceeding, depress front panel OFF button and install both fuses.

CAUTION: ALWAYS REMOVE FUSES WHEN SHIPPING OR STORING RECORDER TO PREVENT POSSIBLE DAMAGE TO BATTERY.

2.4 SIGNAL CONNECTIONS

a. Drive Amplifier Input Signal

Connect signal to INPUT 1 and 2 terminals on front panel. For single-ended input, connect ground strap to terminal 2. For balanced or double-ended input, disconnect ground strap.

NOTE: A positive input to pin 1 will cause the pen to deflect to the left.

b. Event Marker Signals

The event markers are actuated by pushbutton switches located on front panel. The left marker pen deflects to the left, right marker pen deflects to the right. Event markers may also be actuated by external switch closure (short) across terminals located on rear panel.

NOTE: Resistance of each event marker coil is 600 ohms and has +12 volts d-c connected from an internal source.

c. External d-c Power Output

Battery voltage (fused and switched) is available at rear 6 pin connector. (Mating connector is 269570). Voltages available are

PIN	VOLTAGE
1	System Ground
2	+6 volts
3	NC
4	–6 volts
5	NC
6	NC

d. External D-C Chart Drive Input

To make use of the External D-C Chart Drive Input, connect d-c input (0–5 volts) directly to plug assembly 682505. This plug assembly contains a series 10K ohm current limiting resistor.

For operational information, refer to Para. 3.6.

2.5 INSTALLATION OF POWER ADAPTER MODULE

Refer to Figure 2-1 and perform the following:

1. Disconnect recorder from power source (if connected) and depress OFF button.

2. Remove battery cover by removing four phillips-head screws securing cover to recorder.

3. Adapter may be removed by sliding adapter out of recorder connector.

4. To install adapter, align card-edge with card guide in recorder, and insert adapter until adapter is tightly seated in recorder.

5. Replace battery cover using four phillips-head screws removed in step 2.

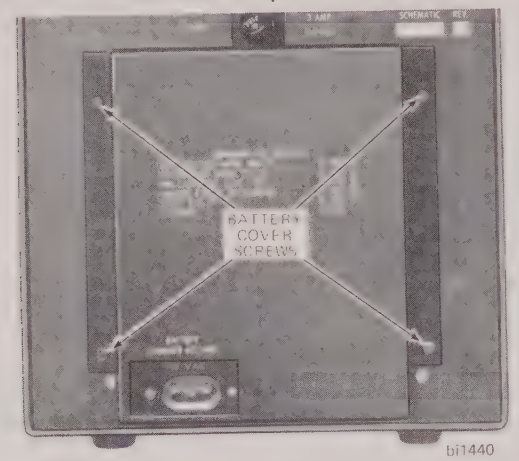


FIGURE 2-1 REMOVING BATTERY COVER

2.6 CHART TAKEUP INSTALLATION (MODEL 11-6402-03)

Refer to Figure 2-2 and perform the following:

1. Disconnect recorder from power source, if connected.

2. Remove recorder from case (refer to Para. 4.3a).

3. Remove shorting straps from input terminals and set aside.

4. Remove two fuses on rear of unit and set aside.

5. Remove power supply board asm. from bottom-left side plate by disconnecting circuit board connector, removing phillips-head screw and popping board free of plastic board holders.

6. Remove Ink Control and Motor Servo Board Asm. from bottom-right side plate by

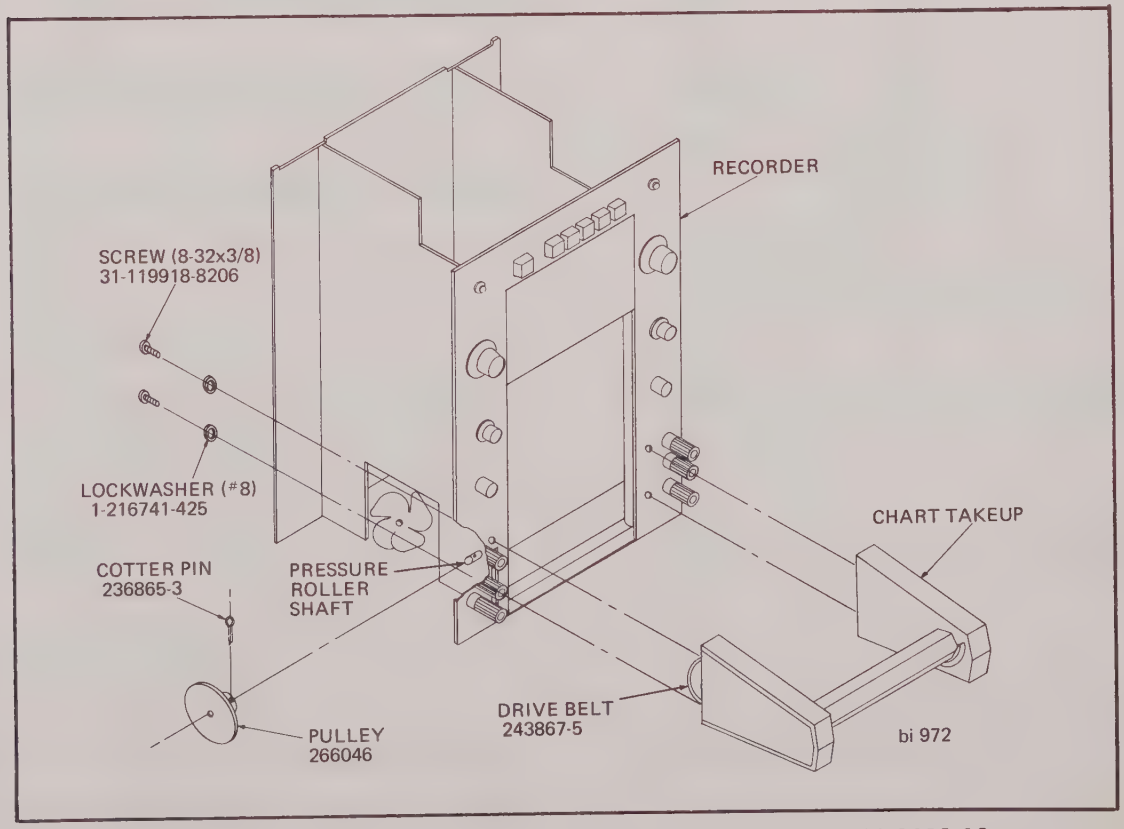


FIGURE 2-2 INSTALLATION OF CHART TAKEUP, MODEL 11-6402-03

disconnecting circuit board connector, removing phillips-head screw and popping board free of plastic board holders.

NOTE: Use caution in removing connectors so as not to damage wires in harness.

7. Remove screw, ground lug and shield can from rear of both sets of input terminals.

8. Loosen nuts on rear of middle binding post of both sets of input terminals, to allow shield mounting bracket to rotate freely on binding post.

9. Remove drive belt and drive pulley from drive roll. Use care not to damage plastic drive pulley.

NOTE: Take care not to lose metal spacers located behind drive pulley.

10. Remove and discard two plastic caps covering slots in front panel.

11. Position chart takeup on front panel so that takeup drive belt is located on left side of recorder.

12. Attach both chart takeup arms to front panel using four screws and four lockwashers.

13. Slide pulley onto pressure roller shaft (left side of recorder) and secure with cotter pin.

14. Position chart takeup drive belt around pulley.

15. Replace drive pulley (right side of recorder) and replace drive belt.

16. Position shield mounting brackets on both sets of input terminals, and tighten nuts on both middle terminals.

17. Attach shield cans, with ground lugs, with screws removed in step 7, to shield mounting bracket.

18. Install both printed circuit boards removed in steps 5 and 6, above.

19. Install two fuses on rear of unit.

20. Install two shorting straps on input terminals.

21. Install recorder in case (refer to Para. 4.3b).

2.7 INTERCHANNEL EVENT MARKER INSTALLATION (MODEL 11-6221-00)

Refer to Figures 2-3 and 4-5 and perform the following:

1. Disconnect recorder from power source if connected.

2. Remove recorder from case (refer to Para. 4.3).

3. Remove pen access cover.

4. Secure Event Marker to penmotor mounting bar with self-tapping screws.

5. Splice nine inch brown wire to brown wire attached to event marker.

6. Connect yellow/white wire attached to event marker to terminal 3 of TB-302.

7. Install jacks into existing holes in rear panel.

8. Attach capacitor across jacks (do NOT solder).

9. Solder one end of brown lead to one end of capacitor and jack as shown.

10. Solder one end of white 4-inch lead to capacitor and jack as shown.

11. Solder other end of 4-inch lead to existing jack as shown.

12. Install pen on Event Marker (refer to Para. 4.5).

13. Remove cap from manifold nipple and connect ink tubing from pen to ink manifold nipple.

14. Turn ink valve control clockwise to ON position.

15. Check and adjust pen pressure (Para. 4.7).

16. Lap pen if required (Para. 4.8).

17. Install recorder in case (Para 4.3).

18. Replace pen access cover.

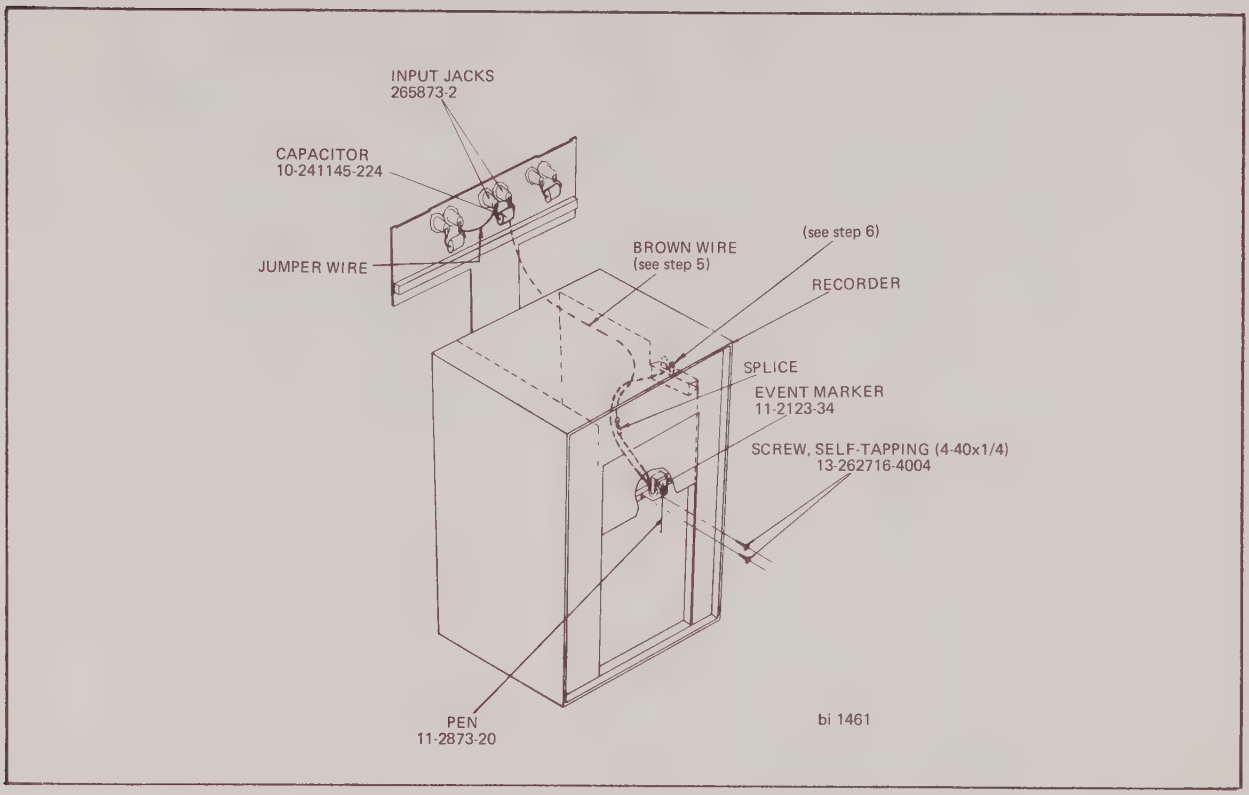


FIGURE 2-3 INSTALLATION OF INTERCHANNEL EVENT MARKER, MODEL 11-6221-00

2.8 ONE-SECOND TIMER INSTALLATION (MODEL 11-6101-41)

Refer to Figure 2-4 and perform the following:

1. Disconnect recorder from power source if connected.
2. Remove recorder from case (refer to Para. 4.3).
3. Remove four screws securing battery cover to rear panel and remove battery (refer to Para. 4.9).
4. Remove Input Power Adapter Module. (refer to Para. 2.5).
5. Remove four phillips-head screws securing back cover to recorder.
6. Relieve pressure on ink cartridge (refer to Para. 4.10, a3).

NOTE: Relieving pressure on cartridge will prevent ink escaping if tubing is accidently pulled from cartridge.

7. Position timer on outside of left hand sideplate and attach with two screws.
8. Position timer ON-OFF switch on upper left-hand corner of rear panel and attach with two screws and two lock washers.
9. Attach connector from harness to timer board.
10. Locate four wires tied back to harness near timer ON-OFF switch.
11. Solder one green wire to top center lug of switch; solder other green wire to top left lug of switch.
12. Solder one red wire to bottom center lug of switch; solder other red wire to bottom left lug of switch.
13. Install diode assembly, Brush part number 683384, across terminals 1 and 2 of terminal board TB-301. Banded end of diode connects to terminal 2.

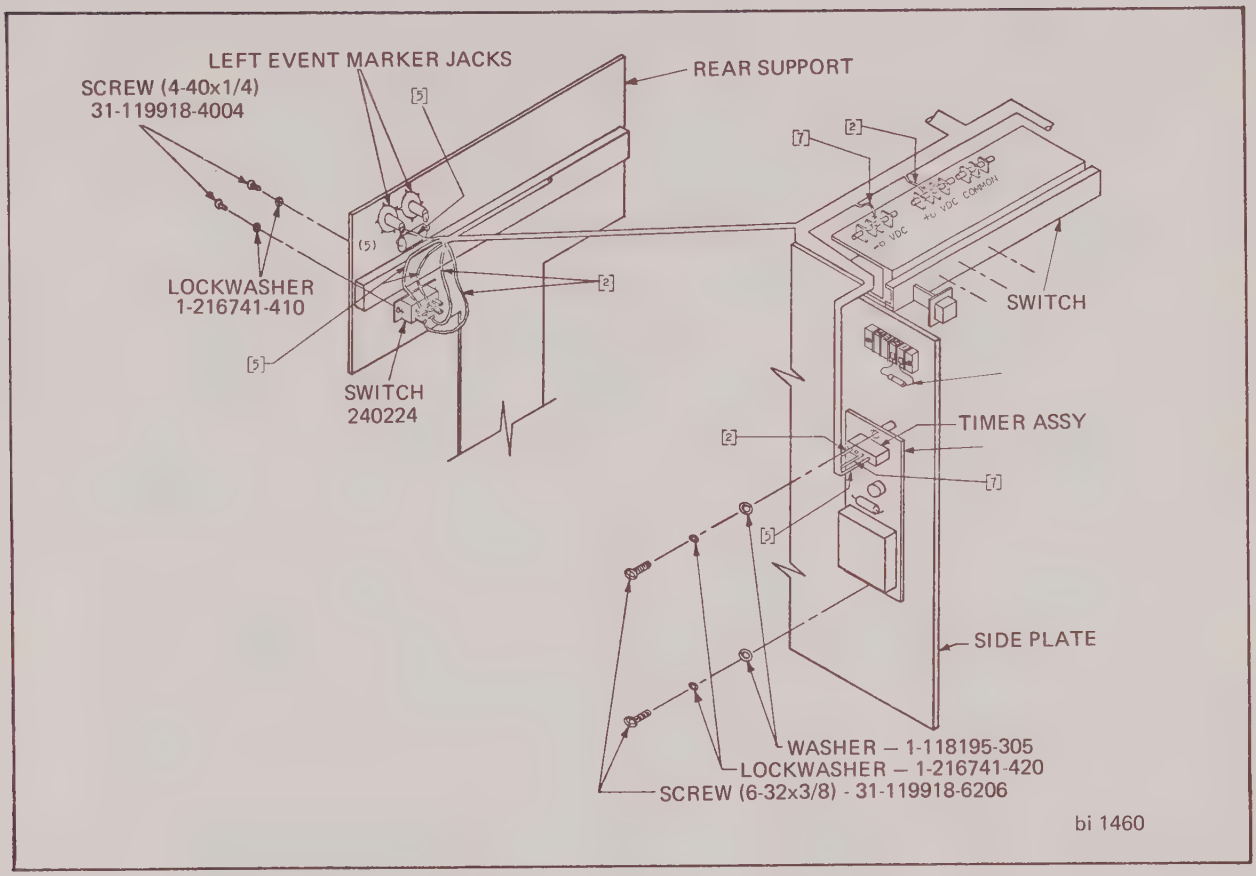


FIGURE 2-4 INSTALLATION – ONE SECOND TIMER MODEL 11-6101-41

14. Apply pressure to ink cartridge (refer to Para. 4.10, b5).

15. Position rear panel on rear of recorder and secure with four screws.

16. Install Input Power Adapter Module (Para. 2.5).

17. Install battery (Para. 4.9) and battery cover.

18. Install recorder in case.

2.9 RACK MOUNTING INSTALLATION

The Brush 222 Recorder may be rack mounted in a standard 19-inch RETMA cabinet using Rack Mounting Kit, Model 11-1202-08.

a. Installation

Refer to Figure 2-5 and perform the following:

1. Remove four screws and rubber feet from bottom of recorder.

2. Attach support bracket to bottom of recorder with four screws and lock washers.

3. Attach two bottom nut bars to cabinet front rails at desired height using two screws and spacers.

4. Position right-hand hanger behind nut bar and attach to front rail with two screws.

5. Position support hanger against rear rail and attach with two screws.

6. Align slotted holes on hanger with holes on support and install two screws.

7. Perform steps 4, 5 and 6 to mount left-hand hanger.

NOTE: The above procedure is used when the rear mounting is a single-bend cabinet rail. If the rear mounting is a multiple bend cabinet rail, the support hanger is not required. Instead, slide two floating nuts, onto the rear rail, position hanger against rail, and attach with two screws as shown on left rear rail in Figure 2-5.

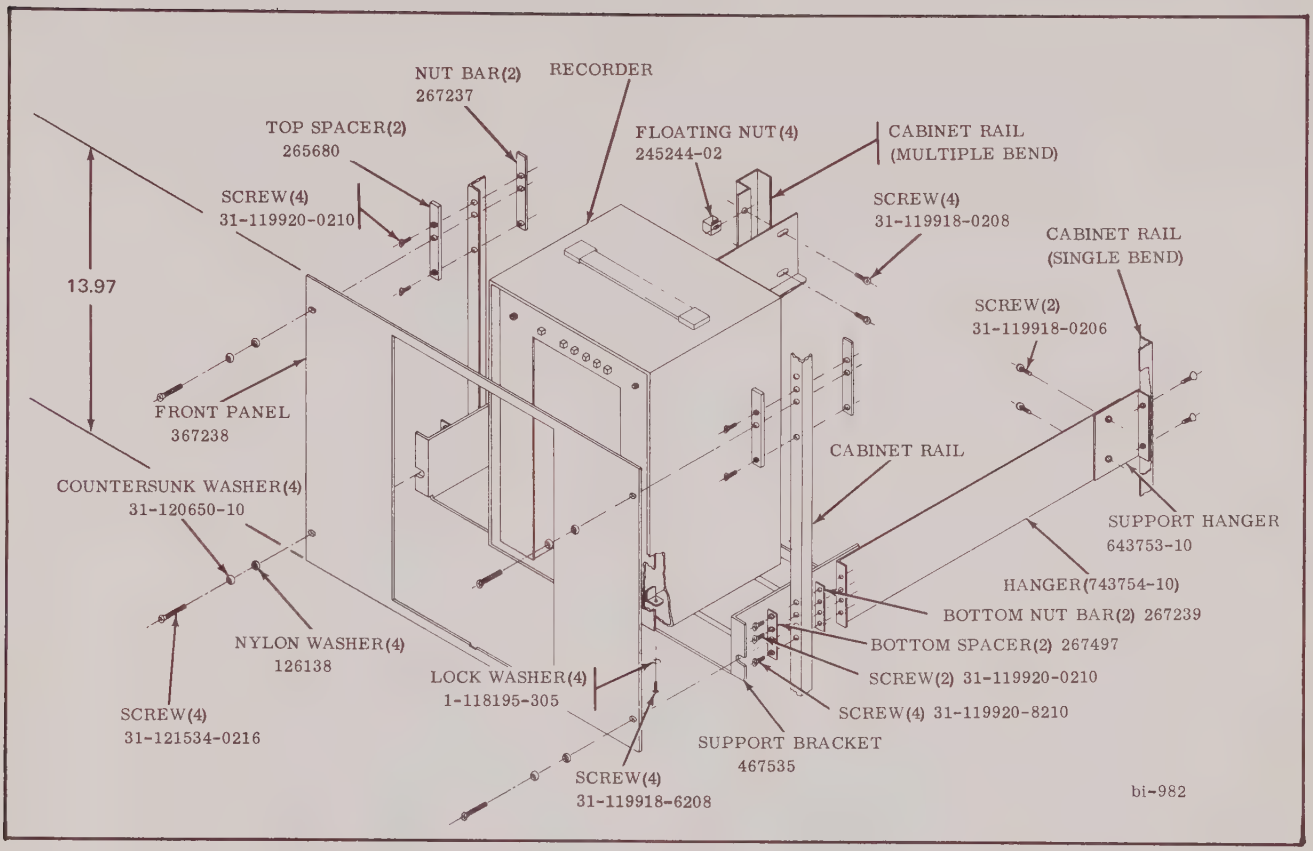


FIGURE 2-5 RACK MOUNTING INSTALLATION, MODEL 11-1202-08

8. Attach two top nut bars to cabinet front rails using four screws and with four screws and spacers.

9. Slide support bracket with recorder attached onto hangers.

10. Position front panel around recorder and attach to front rails with four screws, nylon washers, and countersunk washers.

b. Removal

1. Remove four screws and attaching hardware and remove front panel.

2. Remove four screws and lock washers from support bracket and remove recorder.

2.10 OUTLINE DIMENSIONS

Refer to Figure 2-6 for outline dimensions.

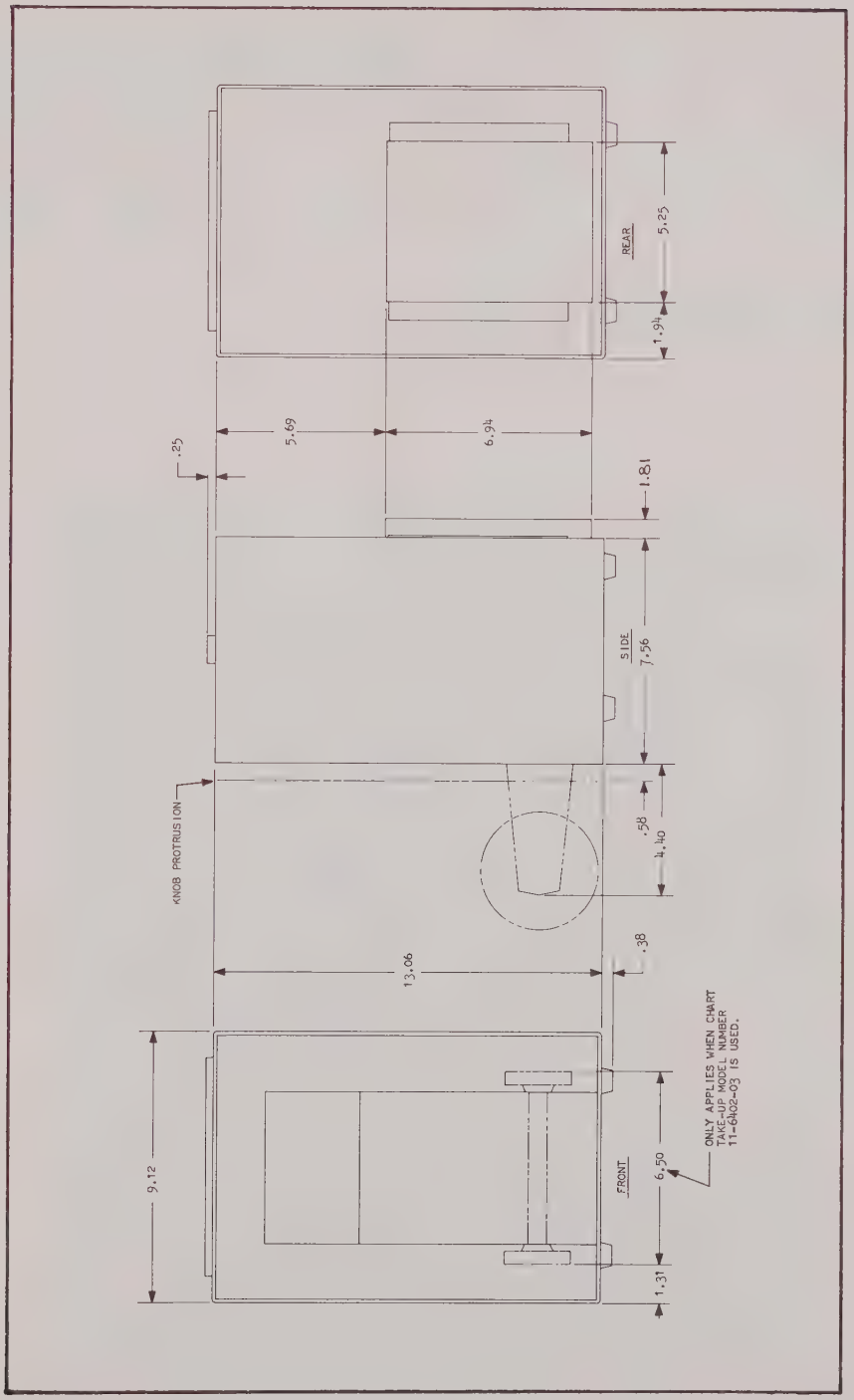


FIGURE 2-6 OUTLINE DIMENSIONS

SECTION III

OPERATION

3.1 GENERAL

This section describes and illustrates the controls on the Brush 222 Recorder and also provides instructions for proper operation.

3.2 FRONT PANEL CONTROLS

NOTE: Item numbers listed below correspond to circled numbers in Figure 3-1.

1 BATTERY . . . . . Meter indicates battery condition. When indicator falls into red area, battery should be recharged.

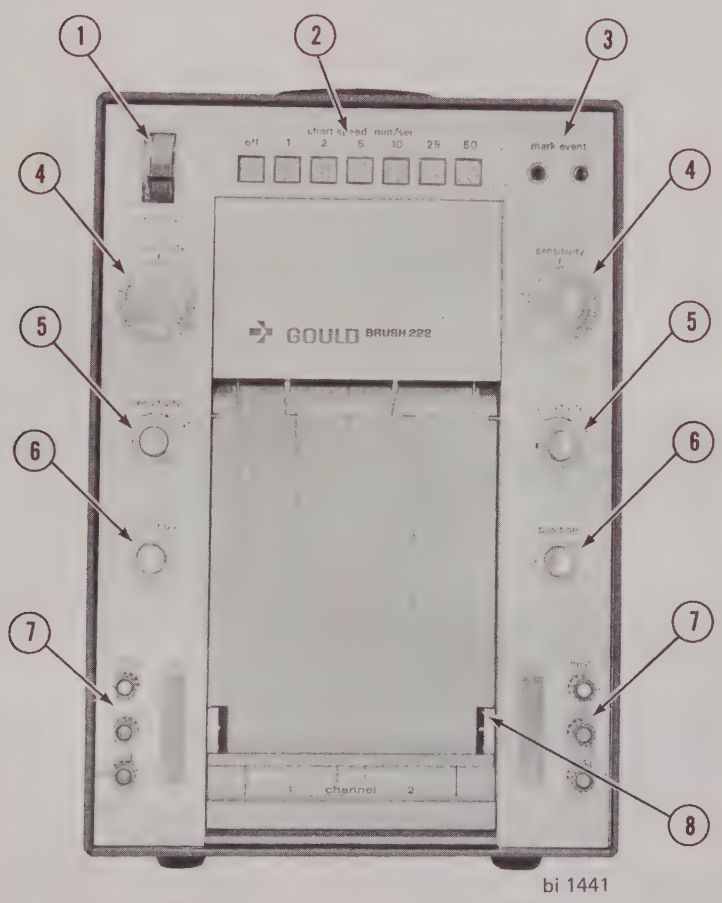


FIGURE 3-1 FRONT PANEL BRUSH 222 RECORDER

2 CHART SPEED . . . . . Seven position switch permits selection of six chart speeds and OFF. When in OFF position, all power is removed from recorder. Depressing any chart speed button activates recorder, and chart will drive at desired speed. Chart speeds may be changed while chart is running.

3 MARK EVENT . . . . . Two momentary switches permit manual marking of an event. When left MARK EVENT button is depressed the left event marker pen will deflect to the left. When the right MARK EVENT button is depressed the right event marker pen will deflect to the right.

NOTE: The event marker pens will remain deflected until the the MARK EVENT button is released.

4 SENSITIVITY . . . . . Provides 13-step attenuation of input signal from one millivolt per division to ten volts per division, and OFF.

5 SENSITIVITY X1 . . . . . Provides intermediate sensitivities between the fixed settings of the stepped sensitivity control. When in the full clockwise x1 (detent) position, the sensitivity is fixed as indicated on the stepped sensitivity control.

When rotated counterclockwise, the sensitivity is less than indicated on the stepped sensitivity control to a maximum ratio of 2.5 to 1. This control is fitted with a locking nut to prevent inadvertent turning.

NOTE: This is a variable control, but not calibrated.

6 POSITION . . . . . Permits pen positioning anywhere within the channel and allows either edge of channel, or any point between to be used as zero signal position. This control is fitted with a locking nut to prevent inadvertent turning.

7 Signal Input Terminals . . . . . Three input terminals are provided for each channel. Shorting strap is removable to provide balanced or floating input. Input is single-ended with shorting strap connected.

8 Writing Table . . . . . Complete assembly consisting of table, writing bar and paper supply shaft. To gain access to the paper supply, pull out on pull bar and swing table up. To close, swing table down into position and push on pull bar until table snaps in place.

NOTE: Writing table must be completely closed or recorder will not operate. Recorder is equipped with an interlock circuit which prevents operation when writing table is not properly closed or when paper supply is exhausted.

3.3 REAR PANEL

NOTE: Item numbers listed below correspond to circled numbers in Figure 3-2.

1	Right Event Marker	Two jacks which, when shorted together by relay or switch closure, permit actuation of the right event marker to the right (refer to Para. 2.4b). Pen will remain deflected until short is removed.
2	Case Ground	Terminal post for use in making connections to case ground.
3	Center Event Marker (optional)	Two jacks which actuate optional center event marker (refer to item 1 above).

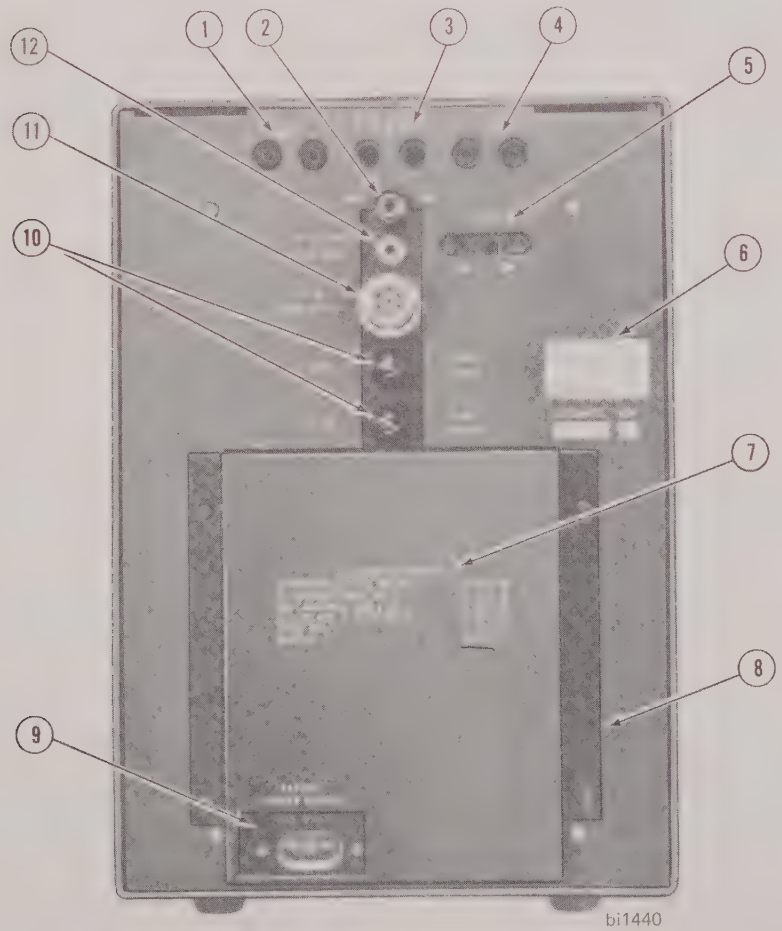


FIGURE 3-2 REAR PANEL BRUSH 222 RECORDER

4	Left Event Marker	Two jacks which actuate left event marker (refer to item 1 above).
5	TIMER (optional)	Provides internal one-second pulses to actuate right event marker.
6	Name Plate	This plate lists the complete model number and serial number of the unit. Input voltage and frequency requirements, along with total unit power consumption are also listed. Immediately below this name plate is the schematic number and revision letter to which the unit is wired. This number must agree with the schematic number found at the rear of this manual.
7	Supplies List	A list of supplies by correct model number permanently silkscreened on the rear of the recorder. Refer to this list when re-ordering supplies.
8	Battery Cover	This cover must be removed to replace battery or to change Input Power Adapter Module.
9	Input Power Adapter Module	Plug-in adapter to permit recharging recorder battery or "line-assisted" operation. Three modules are available for 115 volts, 50 to 400 Hz; 230 volts, 50 to 400 Hz; or 12 to 33 volts, d-c. **CAUTION: CONNECT RECORDER TO EXTERNAL SUPPLY AS INDICATED ON INPUT POWER ADAPTER MODULE. THIS MAY OR MAY NOT CORRESPOND TO INPUT VOLTAGE AND FREQUENCY PRINTED ON THE RECORDER NAME PLATE.**
10	Fuses	Two fuses protect battery from damage should an overload condition occur.
11	External d-c Power Output	6-pin connector provides plus and minus battery voltage for powering external accessories. This power is switched and fused.
12	External d-c Chart Drive Input	Input jack for external 0 to 5 volt-signal for external chart drive.

3.4 RECORDER SET-UP AND OPERATION

CAUTION: CHECK TO BE SURE ALL PROCEDURES IN SECTION II, INSTALLATION, PARA. 2.3, HAVE BEEN PERFORMED.

When preparing the Brush 222 Recorder for operation, be sure to observe all of the following steps:

1. With signal disconnected and OFF button depressed, open writing table by pulling up on pull bar (see Figure 3-1) and be sure adequate paper for operation is on supply roll, and that it is properly threaded. (See threading diagram on side of writing table). If paper supply is exhausted or improperly threaded, refer to Para. 4.2 for complete instructions for changing chart paper. Close writing table firmly.

2. Install two fuses on recorder rear panel (fuses are removed during storage or shipment).

3. Momentarily depress any chart speed pushbutton to check battery condition on battery indicator. Indicator should read in green area. If indicator reads in red area, depress OFF pushbutton and connect unit to proper voltage and frequency as indicated on Input Power Adapter Module.

4. If battery condition checks good, proceed with step 5. If not, allow battery to charge until condition meter indicator is in green area. Then continue with "line assisted" operation.

NOTE: Battery condition must be checked with external power disconnected and recorder chart operating.

CAUTION: IF BATTERY CONDITION READS IN RED AREA, IT IS RECOMMENDED THAT THE UNIT BE CONNECTED AS IN "LINE ASSISTED" OPERATION, BUT THAT RECORDER NOT BE USED. THIS WILL CHARGE THE BATTERY. DO NOT ATTEMPT TO OPERATE RECORDER WITHOUT A BATTERY INSTALLED.

5. Depress 5 MM/SEC chart speed button and operate recorder to insure good ink flow on all channels. If no writing is present after first one foot of paper, refer to Para. 4.11 and check ink cartridge for adequate ink.

6. Set SENSITIVITY control to OFF position.

7. Turn SENSITIVITY X1 control to full clockwise position (detent) and secure with locking knob.

8. Depress 5 MM/SEC chart speed button, and connect input signal.

9. Position pen at exact chart center or any other position desired as signal-zero position with the POSITION control. Lock knob in this position.

10. Switch SENSITIVITY control to a range that will permit maximum pen deflection without going beyond chart edge.

11. Chart deflection will be proportional to the SENSITIVITY control setting for the voltage being recorded.

12. Select a chart speed that will best display the signal with respect to the frequency of the signal.

NOTE: Power is removed from recorder by a paper interlock switch when paper supply is exhausted. Because of the necessity of keeping paper under pens at all times, some unused paper will remain on the roll.

3.5 OPERATION WITH BRUSH PREAMPLIFIERS AND COUPLERS

When using this recorder in conjunction with any Brush preamplifier or coupler, proceed as follows to insure proper operation.

1. Set recorder SENSITIVITY to OFF position.

2. Adjust recorder POSITION control to position pen at exact chart center and lock knob.

3. Check that recorder vernier SENSITIVITY X1 control is in the detent position, and lock knob.

4. Set recorder SENSITIVITY to 100 MV/DIV.

5. Connect preamplifier output to recorder in such a way that turning the preamplifier POSITION control clockwise will move the pen to the right. The recorder shorting strap may have to be disconnected, depending on the output polarity of the preamplifier or coupler.

3.6 EXTERNAL D-C CHART DRIVE

The Brush 222 Recorder chart drive can be operated by an external d-c source. A voltage of 100 millivolts will operate the chart at 1 mm/sec (slowest) and 5.0 volts will operate the chart at 50 mm/sec (fastest). Voltage and chart speeds are directly proportional between listed minimums and maximums.

Because of design techniques to conserve battery power, speeds of 1, 2, 5 and 10 mm/sec produce less current drain than 25 mm/sec, and 25 mm/sec is less than 50 mm/sec. Consequently, if remote voltage is above 100 millivolts but does not exceed 1.0 volt, depress 10 mm/sec chart speed button. If remote voltage is greater than 1.0 volt, but does not exceed 2.5 volts, depress 25 mm/sec chart speed button. If remote voltage is greater than 2.5 volts, depress 50 mm/sec chart speed button.

NOTE: A chart speed button must be depressed to operate recorder. Chart speed button depressed determines fastest remote chart speed possible.

Current drain on external voltage source is less than 1 milliamp.

3.7 OPERATIONAL NOTES FOR BRUSH 222 RECORDER

a. Automatic Ink Shutoff

To prevent erroneous recordings because of low battery voltage, the circuitry provides automatic ink shutoff when battery voltage drops to a marginal level (this level is coincident with crossover from green to red area on battery condition meter).

Stop recorder chart by depressing OFF pushbutton. Do not operate recorder unless recorder batteries are recharged, or "line assisted" operation is used.

CAUTION: IF RECORDER IS USED WITHOUT RECHARGING BATTERY, SO THAT BATTERY CONDITION METER INDICATES IN THE RED AREA WHILE UNIT IS OPERATING, INK SYSTEM WILL NOT AUTOMATICALLY SHUT-OFF, AND MUST BE SHUT-OFF BY DEPRESSING OFF PUSHBUTTON.

b. Rechargable Battery

To obtain the maximum life from the rechargable gelite battery, observe the following notes.

1. Gelite battery's shelf life characteristics vary with storage temperature. Charge retention at 68° F is:

   1 month 97%
   3 months 91%
   6 months 82%

   Lower ambient temperatures will extend shelf life whereas higher ambient temperatures will decrease it.

2. Gelite battery's overall performance will be best if the battery is permitted to "cycle" completely during use. This means that a fully charged battery should be allowed to discharge fully, under load, and then be fully charged using the recorder charger.

NOTE: During the charge period the recorder may be used, as in "line assisted" operation.

SECTION IV

MAINTENANCE

4.1 GENERAL

This section describes and illustrates removal, installation, and adjustment procedures that can normally be performed by the operator.

4.2 CHANGING CHART PAPER

This paragraph describes and illustrates the procedures for changing the chart paper.

NOTE: The last 50 feet of all Brush chart paper is identified by a blue line moving from right edge to left edge. When blue line crosses chart center, approximately 25 feet of paper remain.

a. Removal

1. Press chart speed OFF button.
2. Grasp pull bar (Fig. 4-1) on bottom of writing table and pull out and up to place writing table in open position.
3. Hold paper supply core and shaft and pull down on paper supply release lever (Fig. 4-2) and remove paper supply core and shaft.
4. Unscrew paper core from supply roll shaft and discard paper core.

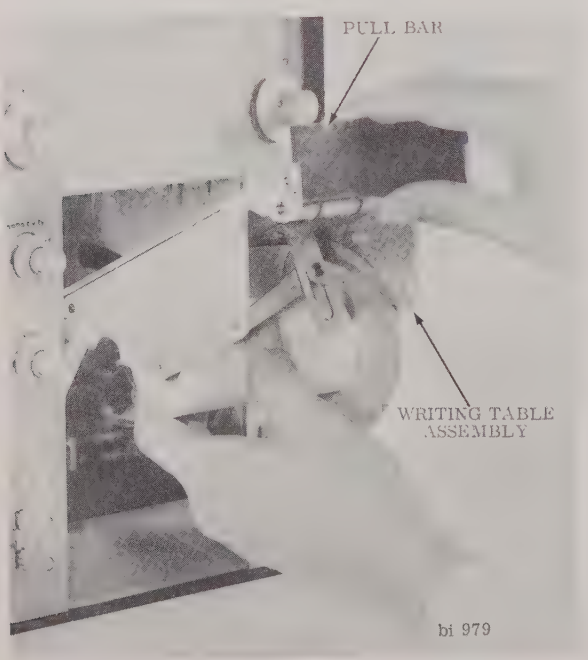


FIGURE 4-1 CHANGING CHART PAPER

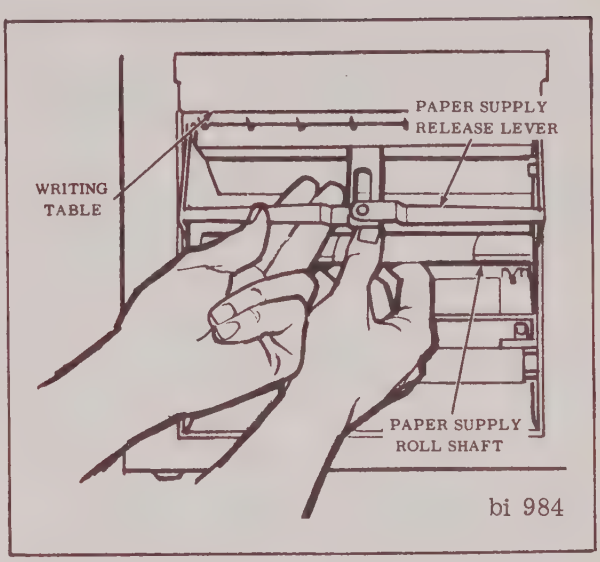


FIGURE 4-2 CHANGING CHART PAPER

b. Installation

1. Slide new roll of paper onto supply roll shaft.

NOTE: Check to be sure flange of shaft is at right side adjacent to channel 2 on chart paper and paper unwinds from top of roll.

2. Screw supply roll shaft into paper core so that flange is snug against paper core.

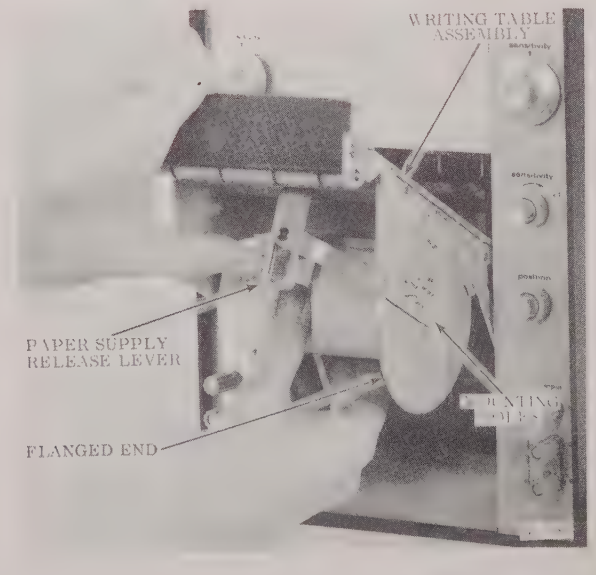


FIGURE 4-3 CHANGING CHART PAPER

3. Insert flanged end of paper supply roll shaft into shaft mounting holes in writing table assembly (Fig. 4-3), and push up on release lever to lock shaft into position.

CAUTION: CHECK TO BE SURE LEFT END OF SUPPLY ROLL SHAFT IS SEATED IN WRITING TABLE ASSEMBLY AND SUPPLY ROLL SHAFT ROTATES FREELY.

4. Feed paper over writing bar, through slot in front of writing table, behind pressure roll and out front of writing table assembly (Fig. 4-4).

NOTE: Refer to paper threading diagram on side of writing table assembly.

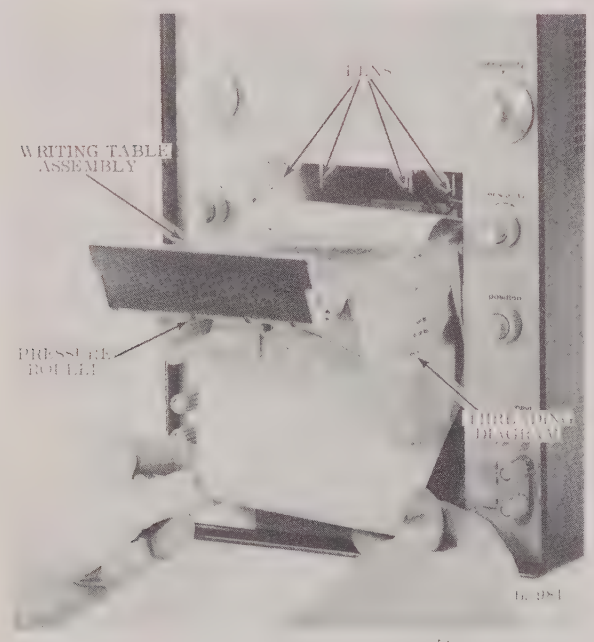


FIGURE 4-4 CHANGING CHART PAPER

CAUTION: USE CARE DURING PAPER THREADING NOT TO DAMAGE PENS.

5. Slowly close writing table assembly while gently pulling on paper. When friction resists rotation of paper roll, pull paper taut, center on writing table, and gently but firmly close writing table.

NOTE: Check to be sure writing table is properly engaged by pressing on both sides of writing table.

6. Turn recorder on and operate at 50 millimeters per second to run about two feet of chart paper to align chart paper.

4.3 COVER ASSEMBLY

The cover assembly must be removed to perform certain maintenance and calibration procedures on the recorder.

WARNING: CHECK TO BE SURE RECORDER IS TURNED OFF AND DISCONNECTED FROM EXTERNAL POWER SOURCE.

a. **Removal**

1. Lay recorder on side panel and remove four screws attaching rubber feet and cover assembly to bottom of recorder.

2. Return recorder to upright position.

3. Carefully slide recorder forward out of cover assembly, being careful not to damage circuit boards.

b. **Installation**

1. Carefully slide recorder into front of cover assembly, being careful not to damage circuit boards.

CAUTION: CHECK TO BE SURE WIRES ARE NOT PINCHED BETWEEN COVER AND RECORDER CHASSIS.

2. Lay recorder on side panel and install four screws attaching rubber feet and cover to recorder.

3. Return recorder to upright position.

4.4 REPLACING ANALOG PEN

This paragraph describes and illustrates the procedures for removing and installing the analog pens.

a. **Removal**

1. Remove pen access cover (located above writing table) by pulling out on bottom of access cover.

2. Use a screwdriver and rotate individual ink valve button to OFF position (Fig. 4-5).

3. Gently remove pen ink tube from manifold nipple.

NOTE: Place a tissue under nipple and ink tube to prevent ink dripping on recorder components.

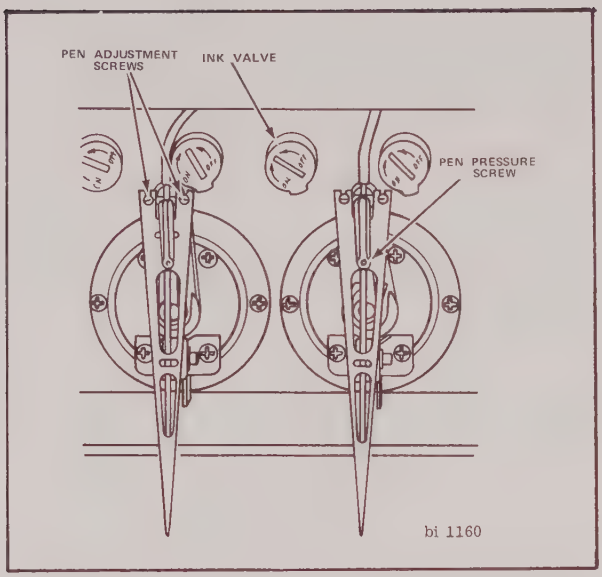


FIGURE 4-5 REPLACING ANAOLG PEN

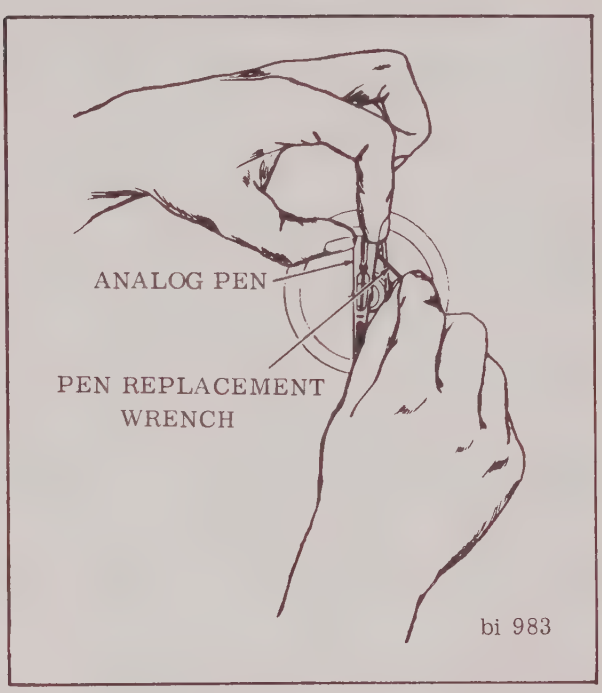


FIGURE 4-6 REPLACING ANALOG PEN

4. Use pen replacement wrench (part number 1-120922-2) and loosen set screw through access hole on side of penmotor drive arm shaft (Fig. 4-6) and remove wrench.

NOTE: Do not loosen set screw more than one-half turn or pen cannot be removed from shaft.

5. Remove pen from penmotor drive arm shaft.

b. Installation

1. Carefully slide replacement pen onto penmotor drive arm shaft.

2. Align set screw in pen hub with access hole in drive arm shaft and "snug up" set screw using pen replacement wrench. Remove wrench.

NOTE: Set screw should be tightened to create friction, but loose enough to allow pen to be rotated in penmotor hub.

3. Install proper pen tube (3.34" long with right angle bend) between manifold and pen.

CAUTION: DO NOT USE SHARP INSTRUMENT.

4. Use screwdriver and turn individual ink valve button to ON position.

5. Operate recorder at five millimeters per second.

6. Use pen POSITION control, and place pen at chart center.

7. Lift pen slightly to allow ink to bleed through pen tip.

8. Press recorder chart speed OFF button.

9. Gently grasp pen near hub and move pen across entire chart width (40mm).

10. If ink trace is not parallel to a horizontal time line, gently turn pen in penmotor drive arm until trace is parallel to time line.

11. Use pen replacement wrench, tighten set screw securing pen in penmotor drive arm shaft and remove wrench.

12. If pen tip is not on same time line as other pens, loosen two pan head adjustment screws (Fig. 4-5) and slide pen up or down until all pen tips are on same time line, and tighten screws.

13. Check pen pressure and adjust if required (Para. 4.8).

NOTE: The following steps pertain to Pen, Model 11-2823-33 only. For instructions on Extended Life Pen, Model 11-2823-34, refer to Para. 4.13.

14. New pen must be lapped before proceeding. Carefully raise pen tip just enough to slide a small strip of emery paper (3M wet or dry Tri-M-ite paper, Grit M-600, Brush part number 669234) under pen tip.

15. Move pen back and forth five or six times.

CAUTION: MAKE SURE THAT EMERY PAPER IS HELD FLAT AGAINST THE CHART PAPER TO INSURE PROPER LAPPING OF PEN.

16. Remove emery paper, operate recorder at 5 MM/SEC and check pen for dryness.

17. If writing is not dry, proceed with normal pen lapping as described in Para. 4.9.

18. Install pen access cover.

4.5 REPLACING EVENT PEN MODEL 11-2873-20

This paragraph describes and illustrates removal and installation of the event marker pen.

a. **Removal**

1. Remove pen access cover (located above writing table) by pulling out on bottom of access cover.

2. Use a screwdriver and rotate event marker individual ink valve button to OFF position.

3. Gently remove pen ink tube from manifold nipple (do NOT use sharp instrument).

NOTE: Place a tissue under nipple and ink tube to prevent ink dripping on recorder components.

4. Loosen two screws attaching pen to event marker and remove pen from event marker (Fig. 4-6).

b. **Installation**

1. Slide replacement pen onto event marker and align pen tip on vertical grid line and on same time line as analog pen.

2. Tighten two screws attaching pen to event marker (Fig. 4-6).

3. Install proper pen tube (5.6" long) between manifold and pen.

4. Use screwdriver and rotate event marker ink valve button to ON position.

5. Operate recorder at 5 MM/SEC.

6. Lift pen slightly to allow ink to feed through pen tip.

7. Check pen pressure and adjust if required (Para. 4.8).

8. New pen must be lapped before proceeding. Carefully raise pen tip just enough to slide a small strip of emery paper (3M wet or dry Tri-M-ite paper, Grit M-600, Brush part number 669234), under pen tip.

9. Move emery paper up and down five or six times, parallel to division lines.

CAUTION: MAKE SURE THAT EMERY PAPER IS HELD FLAT AGAINST THE CHART PAPER TO INSURE PROPER LAPPING OF PEN.

10. Remove emery paper, operate recorder at 5 MM/SEC and check pen for dryness.

11. If writing is not dry, proceed with normal pen lapping as described in Para. 4.8.

12. Install pen access cover.

4.6 REPLACING PENMOTOR BAND ASM ON PENMOTOR 881908 (Fig. 4-7)

NOTE: Refer to Para. 4.7 for band replacement on penmotor 883300.

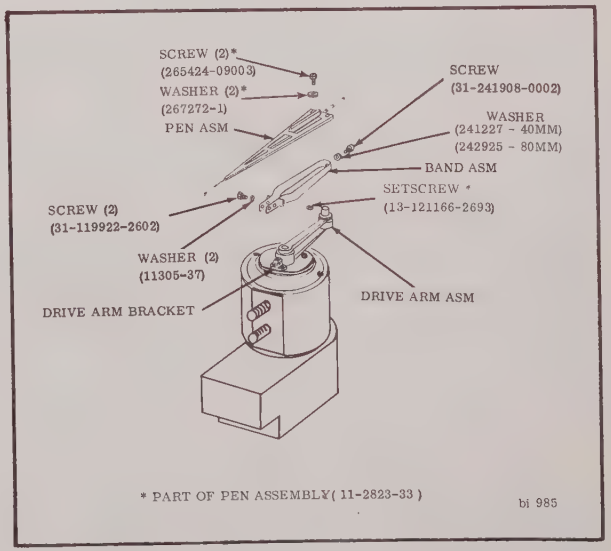


FIGURE 4-7 PENMOTOR ASSEMBLY

The penmotor band assembly (part number 680294) should not be removed unless broken. Because the band tension is critical, a band replacement tool (part number 341409-915) must be used to replace band assembly.

NOTE: Penmotor need not be removed from recorder.

1. Remove analog pen (Para. 4.4).

2. Remove socket-head screw and band clamping (curved) washer that secures band assembly to drive arm (use wrench 1-120922-3).

3. Remove two socket-head screws and flat washers securing band assembly to drive arm bracket (use wrench 245218-5). Discard damaged band assembly.

CAUTION: TO PREVENT DAMAGE TO THE NEW BAND ASSEMBLY, CHECK TO BE SURE DRIVE ARM AND BRACKET ARE FREE OF NICKS, DIRT, INK BEFORE INSTALLING NEW BAND ASSEMBLY.

4. Position new band assembly around drive arm hub. Align mounting holes with tapped holes in drive arm bracket and install two screws and lock washers. Do not tighten screws.

NOTE: Check to be sure curved portion of washer is positioned to conform to the radius of the drive arm hub. Use care not to nick or scratch band assembly.

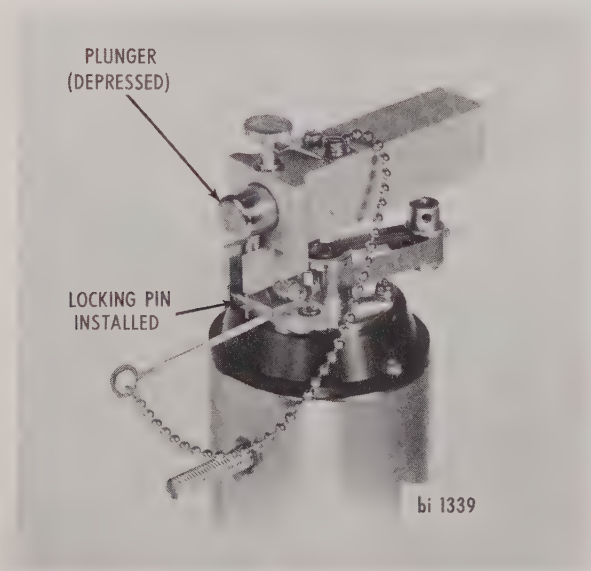


FIGURE 4-8 BAND TOOL MOUNTING

5. Carefully install band clamping washer and socket-head screw.

6. Inspect band for proper positioning around drive arm hub so that equal pressure is maintained on top and bottom of band assembly.

7. Install band tool on penmotor and thread knurled thumb screw into drive arm bracket. (Figure 4-8).

8. Depress plunger and insert locking pin into two small holes of band assembly, making certain plunger is behind locking pin.

9. Tighten two screws in drive arm bracket, loosen one quarter-turn, move drive arm back and forth several times to center band assembly and tighten screws.

10. Move drive arm back and forth several times to center band assembly on drive arm and tighten socket-head screw securing band assembly to drive arm.

NOTE: Do not tighten more than 22 inch-ounces.

11. Depress plunger and remove locking pin.

12. Loosen knurled screw securing band tool to drive arm bracket and remove tool.

13. Apply glyptal cement (or equivalent) to heads of the three screws to prevent working out.

14. Install analog pen (Para. 4.4).

4.7 REPLACING PENMOTOR BAND ASM ON PENMOTOR 883300 (Fig. 4.9)

NOTE: Refer to Para. 4.6 for Band replacement procedures on penmotor 8819088.

The penmotor band assembly (part number 680294) should not be removed unless broken. Because band tension is critical, a band replacement tool (part number 341409-915) must be used to replace band assembly.

NOTE: Penmotor need not be removed from recorder.

1. Remove analog pen (Para. 4.4).

2. Remove socket-head cap screw and band clamping (curved) washer that secures band assembly to drive arm (use wrench 1-120922-3).

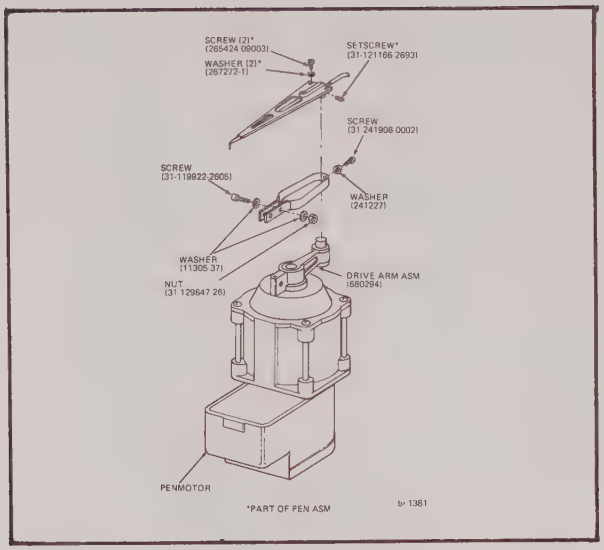


FIGURE 4-9 PENMOTOR ASSEMBLY

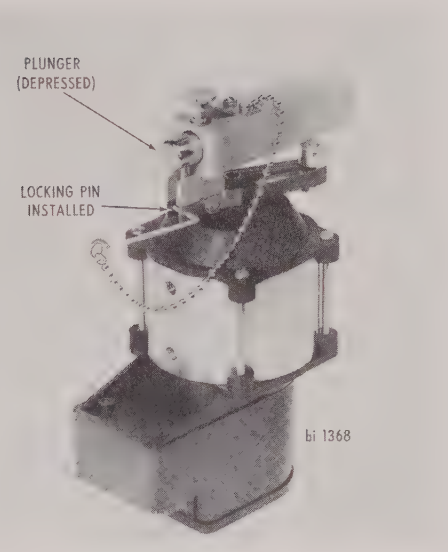


FIGURE 4-10 BAND TOOL MOUNTING

3. Remove socket-head cap screw, hex nut and two flat washers that secure band assembly to penmotor (use wrench 245218-5). Discard damaged band assembly.

CAUTION: TO PREVENT DAMAGE TO THE NEW BAND ASSEMBLY, CHECK TO BE SURE DRIVE ARM AND BRACKET ARE FREE OF NICKS, DIRT, INK BEFORE INSTALLING NEW BAND ASSEMBLY.

4. Position new band assembly around drive arm hub. Align mounting holes with tapped holes in drive arm bracket and install two screws and lock washers. Do not tighten screws.

NOTE: Check to be sure curved portion of washer is positioned to conform to the radius of the drive arm hub. Use care not to nick or scratch band assembly.

5. Carefully install band clamping washer and socket-head screw.

6. Inspect band for proper positioning around drive arm hub so that equal pressure is maintained on top and bottom of band assembly.

7. Install band tool of penmotor and thread knurled thumb screw into penmotor (Fig. 4-10).

8. Depress plunger and insert locking pin into two small holes of band assembly, making certain plunger is behind locking pin.

9. Tighten screw in penmotor, loosen one-quarter turn, move drive arm back and forth several times to center band assembly and tighten screw.

10. Move drive arm back and forth several times to center band assembly on drive arm and tighten socket-head screw securing band assembly to drive arm.

NOTE: Do not tighten more than 22 inch-ounces.

11. Depress plunger and remove locking pin.

12. Loosen knurled screw securing band tool to drive arm bracket and remove tool.

13. Apply glyptal cement (or equivalent) to heads of the two screws and nut to prevent loosening.

14. Install analog pen (Para. 4.4).

4.8 PEN PRESSURE MEASUREMENT

Analog or event marker pen pressure should be checked if the ink trace is excessively wide (bleeding), indicating low pen pressure or if pen gouges the chart paper, indicating excessive pen pressure.

NOTE: Wide trace may also indicate an improperly lapped pen. Refer to Paragraph 4.9 for pen lapping procedures.

The gram gage (part number 240601-910) is used

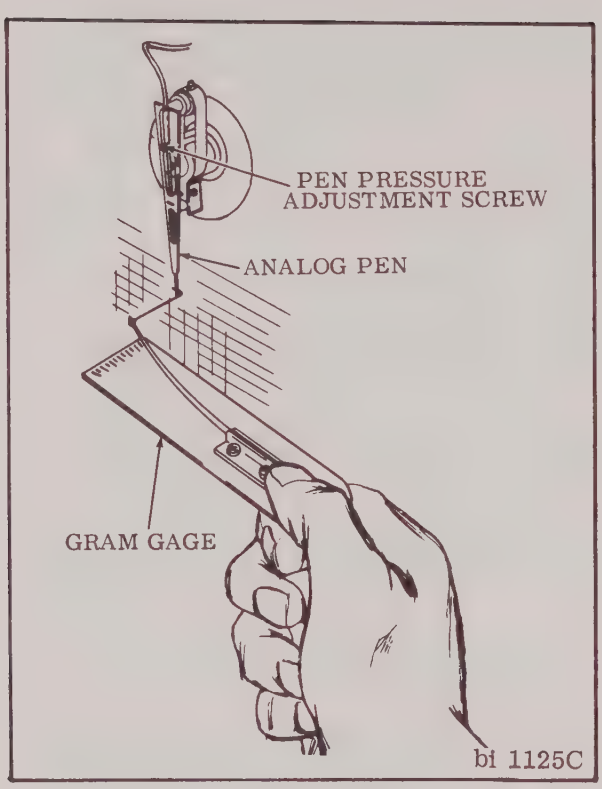


FIGURE 4-11 PEN PRESSURE MEASUREMENT

to measure the pressure of the analog and event marker pens as follows:

1. Turn SENSITIVITY control to OFF position.

2. Remove pen access cover (located above writing table) by pulling out the bottom of access cover.

3. Depress the 1 MM/SEC chart speed button.

4. Place gram gage hook under pen shaft as close as possible to tip and form a right angle to pen shaft with gage hook (Fig. 4-11).

5. Pull pen from chart and take reading on gage the moment excessive ink starts to flow from pen.

6. Proper writing pressure for analog pens is 28 to 32 grams. Event marker pen pressure is 20 to 25 grams.

When pens are replaced, pen pressure must be checked and if required, adjusted as follows:

7. Use pen pressure adjustment wrench (part number 1-120922-18) and turn adjusting screw (Figs. 4-6 and 4-12) clockwise to increase pressure or counterclockwise to decrease pressure.

FIGURE 4-12 PEN PRESSURE ADJUSTMENT

8. Check pen pressure with gram gage and continue adjustment until proper reading is obtained.

9. Install pen access cover. Recorder is ready for operation.

4.9 PEN LAPPING

NOTE: Extended Life Pen, Model 11-2923-34, must be lapped as described in Para. 4.13.

a. General

This paragraph describes and illustrates the proper procedures for lapping the analog and event pens. Intermittent or "wet" ink trace are indications that pen pressure is incorrect or that pen requires lapping. Check for "wet" writing by operating the recorder at 5 MM/SEC chart speed, with the SENSITIVITY control in OFF position. Check pen trace by wiping index finger, with moderate pressure, across trace approximately one inch

below pen tip. If ink does not smear, the pen is properly lapped. If trace smears, check and adjust pen pressure (Para. 4.8). Repeat test, and if trace continues to smear, lapping is required.

b. **Lapping Procedure**

NOTE: Lapping of pens should only be done when required.

1. Depress recorder OFF pushbutton.
2. Remove pen access cover (located directly below chart speed selector switch) by pulling on bottom of access cover.
3. Carefully raise pen tip just enough to slide a small strip of emery paper (4/0, Brush part number 141119) under pen tip.

CAUTION: DO NOT USE A COARSE OR VERY ABRASIVE TYPE OF EMERY PAPER. USE ONLY THE GRADE SPECIFIED.

4. Move pen back and forth for a total distance of approximately two inches. (Fig. 4-13).

CAUTION: MAKE SURE THAT EMERY PAPER IS HELD FLAT AGAINST THE CHART PAPER TO INSURE PROPER LAPPING OF PEN.

5. Remove emery paper, operate recorder at 5 MM/SEC and check pen trace for dryness.

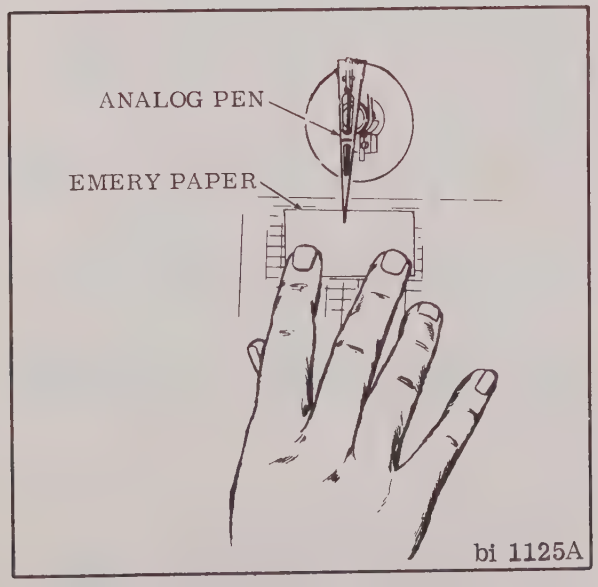


FIGURE 4-13 PEN LAPPING

6. Repeat steps 3 thru 5 as required to obtain dry trace.

NOTE: If procedure is repeated more than three times, recheck pen pressure and repeat lapping. Strict adherence to above lapping procedures is imperative.

7. When dry trace is achieved, replace access cover.

4.10 BATTERY REPLACEMENT

This paragraph describes and illustrates the procedures for replacing battery 281296.

NOTE: Battery may be supplied as either a one-piece or a two-piece unit. However, installation procedures remain the same with the exception that a separator, part number 282982-1, must be used between two-piece battery.

a. **Procedure (see Figures 4-14 and 4-15)**

1. Depress OFF pushbutton.
2. Remove battery cover by removing four phillips-head screws securing battery cover to rear cover.

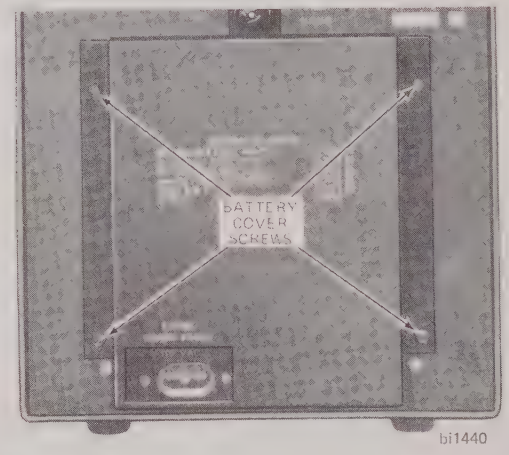


FIGURE 4-14 REMOVING BATTERY COVER

3. Disconnect both black and white plugs connecting battery to recorder.
4. Remove old battery and install new battery so that connecting wires are oriented as shown.

NOTE: If replacement battery is a two-piece unit, insert separator, part number 282982-1, between battery sections.

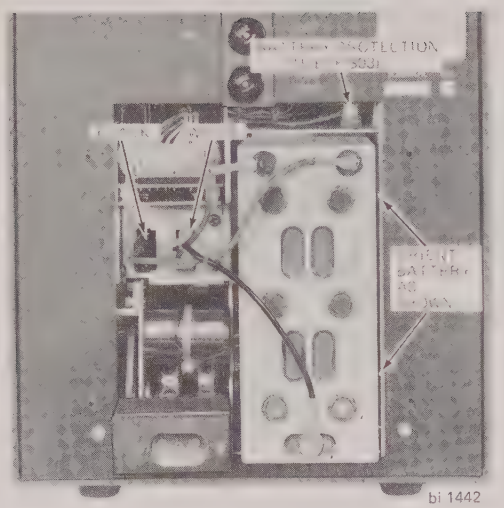


FIGURE 4-15 REPLACING BATTERY

5. Connect white and black plugs to recorder. Be sure to observe correct color-coding (white-to-white, black-to-black) to prevent serious damage to the recorder.

6. Replace battery cover and attach using four phillips-head screws removed in step 2.

7. Depress any chart speed pushbutton and observe that the battery meter reads in the green area and that recorder operates normally.

NOTE: If battery has been stored for extended period, battery may be discharged. Battery must be recharged before using recorder.

8. Recorder is ready for use.

4.11 INK CARTRIDGE REPLACEMENT

This paragraph describes and illustrates the procedures for replacing the Ink Cartridge, Model 11-2730-01.

a. Removal

1. Remove recorder cover assembly (Para. 4.3).

2. Remove four phillips-head screws securing battery cover to rear panel and remove battery (refer to Para. 10).

3. Remove Input Power Adapter Module (if installed) by sliding adapter out of recorder.

4. Remove four phillips-head screws securing back cover to recorder.

5. Turn activating screw (Fig. 4-16) clockwise until compression spring in ink plunger has been drawn up tight into ink plunger assembly and ink flow stopped.

CAUTION: PLACE PAPER TOWELS OR TISSUES UNDER INK SYSTEM TO PREVENT INK DRIPPING ON RECORDER COMPONENTS.

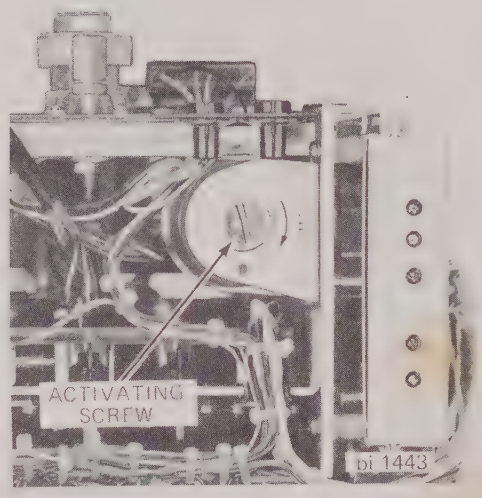


FIGURE 4-16 REPLACING INK CARTRIDGE

6. Carefully remove ink tube from ink cartridge.

7. Unscrew ink cartridge chamber from plunger assembly and discard cartridge.

b. Installation

1. Remove plastic piston retainer ring from replacement cartridge and discard retainer (Fig. 4-17).

2. Install ink cartridge in plunger assembly and tighten securely.

3. Remove shipping cap from ink cartridge and discard shipping cap.

4. Install ink tube on cartridge.

NOTE: Do not use tweezers or other sharp instruments to install tubing.

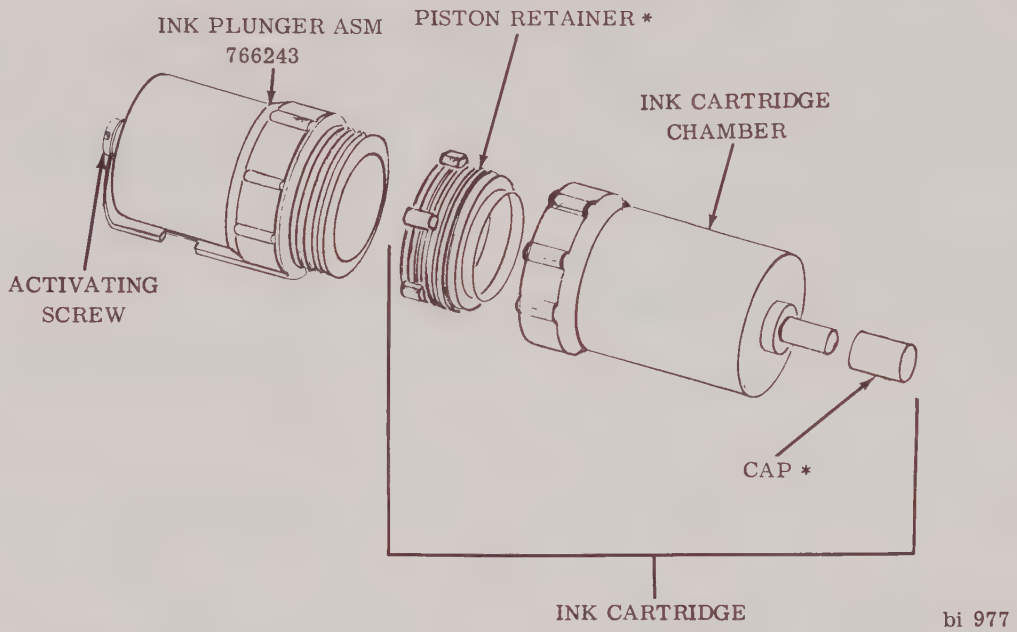


FIGURE 4-17 INK CARTRIDGE, MODEL 11-2730-01

5. Turn activating screw (Fig. 4-16) counterclockwise until snug to pressurize ink system.

6. Install battery in recorder and connect as described in Para. 4.10, step 5.

7. Depress 5 MM/SEC chart speed button to check for proper ink flow.

8. Gently raise each pen tip away from paper and allow ink tube to fill with ink and bleed air from tube until no air bubbles are formed at pen tip.

9. Press recorder OFF button.

10. Remove battery and install back panel using four phillips-head screws removed in step a4 above.

11. Install Input Power Adapter Module, if used, by sliding adapter into recorder.

12. Install battery and battery cover per Para. 4.10.

13. Recorder is ready for use.

4.12 PEN CLEANING

In the event that a pen should fail to write or displays intermittent writing, it may be caused by a clogged pen. The procedure outlined below is intended as a guide to flush pens, but may not always prove effective.

1. Depress recorder OFF pushbutton.
2. Remove pen access cover.
3. Close ink valve on affected channel.
4. Remove ink tubing from manifold.
5. Remove pen (Para. 4.4a or 4.5a).

NOTE: Do not remove tubing from pen unless tubing is kinked or suspected of being defective. Use Brush part number 667277 for analog pen tubing and part number 666587 for event pen tubing.

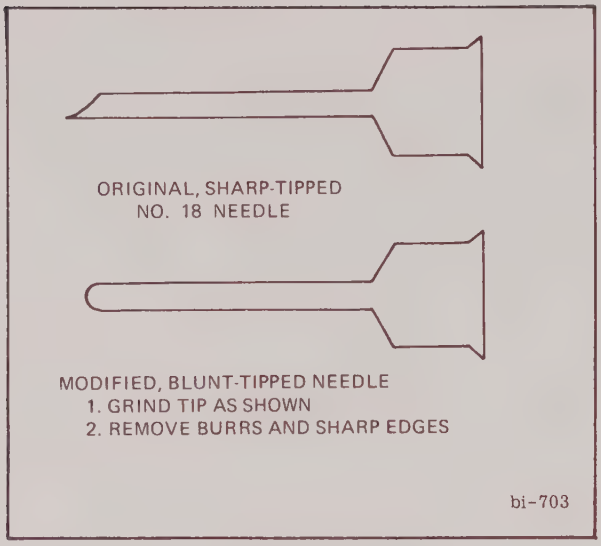


FIGURE 4-18 HYPODERMIC NEEDLE

6. Modify hypodermic needle per Fig. 4-18.

7. Attach modified needle onto 2cc hypodermic syringe.

8. Insert needle in pen tubing.

9. Immerse pen tip in cleaning agent. (Isopropyl Alcohol, Cellosolve, Dowanol EE, or equivalent).

10. Back-flush by slowly withdrawing syringe plunger.

NOTE: It may be necessary to allow the pen to remain in the cleaning agent to dissolve dried ink at pen tip.

11. Install pen (Para. 4.4b or 4.5b).

NOTE: Clogging of pens occurs only when proper adjustment, operating and/or handling as per Brush Operating Manual has not been adhered to.

4.13 LAPPING PROCEDURES FOR EXTENDED LIFE PEN, MODEL 11-2823-34

The Brush Model 11-2823-34 Extended Life Pen requires a different lapping procedure from that described in Para. 4.9. Install pen as described in Para. 4.4, but disregard lapping instructions referred to.

Lap Extended Life Pen as follows:

1. Remove pen access cover.

2. Shut off ink manifold knobs of all channels by rotating all knobs counterclockwise.

3. Raise writing table and rewind chart paper so that no paper is left under pen tips. Be sure sufficient paper is on roll to energize interlock switch to permit recorder operation.

4. Close table and set pen pressure to 30 grams against writing bar.

5. Place coarser of two lapping papers supplied (Brush part number 668963) under pen tip and drive pen at 60 Hz, 1/2 of full scale.

6. Simultaneously move lapping paper back and forth under pen. Lap in this manner for 90 seconds.

7. Now repeat procedure using finer lapping paper (Brush part number 668965) for 90 seconds.

8. Return recorder to normal operating condition (thread chart paper over writing bar and turn ink control knobs on).

NOTE: In most cases, one lapping will suffice, but occasionally two or three will be required to effect a proper seal.

9. If pen tip should become blocked during lapping operation, touch pen at top of bend (above tip) with a hot soldering iron for a few seconds with pen tip slightly raised off paper. This will generally start ink flowing and flush out abrasive.

10. Install pen access cover.

4.14 SCHEMATICS

Before attempting electrical troubleshooting of the Brush 222, check to be sure the schematic number and revision letter stamped on the rear of the unit (Figure 3-2) correspond with the schematic number and revision letter found at the rear of this manual.

Model No.	Schematic
15-6325-00,01,02	282442

SECTION V

CALIBRATION

5.1 GENERAL

The Brush 222 Recorder has been factory calibrated, and under normal conditions will not require calibration. However, because of parts replacement or repair, calibration may be necessary. This section describes and illustrates correct calibration procedures. Calibration should be performed by qualified personnel familiar with procedures and standards.

5.2 TEST EQUIPMENT REQUIRED

NOTE: Specific manufacturer need not be adhered to, but comparable equipment is mandatory to insure calibration accuracy.

a. Two- Digital Voltmeters (Fluke Model 8300A or equivalent).

b. Miniature phone plug (may use Brush part number 682505 with 10K ohm resistor shorted).

c. 1 Hz Timer, Accuracy ±0.25%. (Accessory 1 Second Timer, Model 11-6101-41, may be used).

d. Function Generator (Wavetek Model 110, or equivalent).

e. Oscilloscope (Tektronix Type 503, or equivalent).

5.3 PROCEDURE

1. Remove unit from case (Para. 4.3) and remove battery from recorder (Para. 4.9).

2. Remove Input Power Adapter Module (if installed) and remove back cover by removing four phillips-head screws securing back to recorder.

a. Battery Charger Adjustment

1. Connect digital voltmeter to battery input connectors as shown in Figure 5-1.

2. Insert Input Power Adapter Module into recorder and connect to proper voltage source as indicated on adapter.

3. Adjust resistor, R-404, Figure 5-1, for 13.90 volts ±0.020 volts.

4. Disconnect power source and disconnect digital voltmeter.

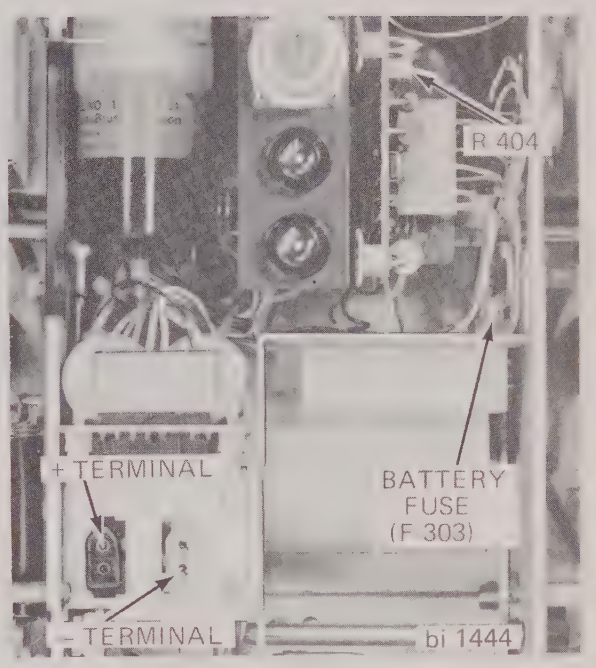


FIGURE 5-1 CALIBRATING CHARGER

5. Install battery in recorder, observing proper color coding (white-to-white, black-to-black) when making connections.

6. Connect Input Power Adapter Module to proper voltage source as indicated on adapter.

b. Power Supply Adjustment

1. Refer to Figure 5-2 and connect scope to test points 1 and 2.

2. Depress 1 MM/SEC chart speed pushbutton.

3. Set scope sensitivity to 10 volts/cm.

4. Adjust resistor, R-306 for best symmetry and clean square corners.

c. Chart Drive Servo Adjustment

1. Refer to Figure 5-2 and connect digital voltmeter to points 3 and 4.

2. Adjust resistor, R-313, for 5.00 volts ±2 mv.

3. Depress OFF pushbutton.

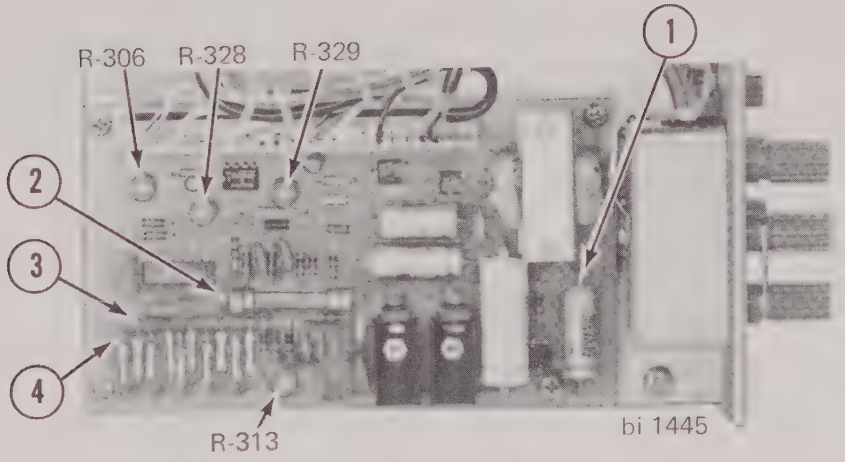


FIGURE 5-2 CHART DRIVE ADJUSTMENTS

4. Insert shorted miniature phone plug (Brush part number 682505, shorted) into rear panel External D-C Chart Drive receptacle.

5. Refer to Figure 5-3 and connect digital voltmeter ground to battery +.

6. Refer to Figure 5-4 and connect digital voltmeter high to point 1.

7. Depress 1 MM/SEC chart speed pushbutton.

8. Refer to Figure 5-2 and adjust resistor, R-329, for zero volts (less than 0.1 millivolt).

9. Remove shorted plug. Chart should now run.

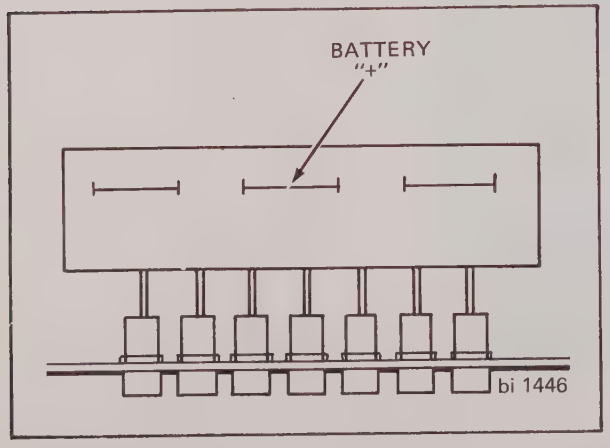


FIGURE 5-3 TEST POINTS

10. Connect accurate (±0.25%) 1 Hz timer to analog channel 1 (left channel).

NOTE: If recorder contains accessory 1 second timer, Model 11-6101-41, it may be used. Connect a 250 pf capacitor between rear left event marker jack (outboard jack only) to analog input terminal 1. Connect ground strap from guard to terminal 2. Turn timer switch on.

11. Depress 10 MM/SEC chart speed button and adjust resistor, R-328 (Figure 5-2) for exactly one timer cycle per ten millimeters of chart.

NOTE: Final adjustment should be made over a 100 second time span (1000 mm of chart).

12. Depress 1 MM/SEC chart speed button and adjust resistor R-520 (Figure 5-4) for accurate chart speed based on 1 second timer pulses.

13. Depress OFF pushbutton and disconnect test equipment.

d. Drive Amplifier Calibration

NOTE: Refer to Figure 5-5 as necessary. Remove metal shield by removing four phillips-head screws. One channel typical of two.

1. Depress 1 MM/SEC chart speed pushbutton.

2. Refer to Figure 5-5 and connect digital voltmeter to points 1 and 2.

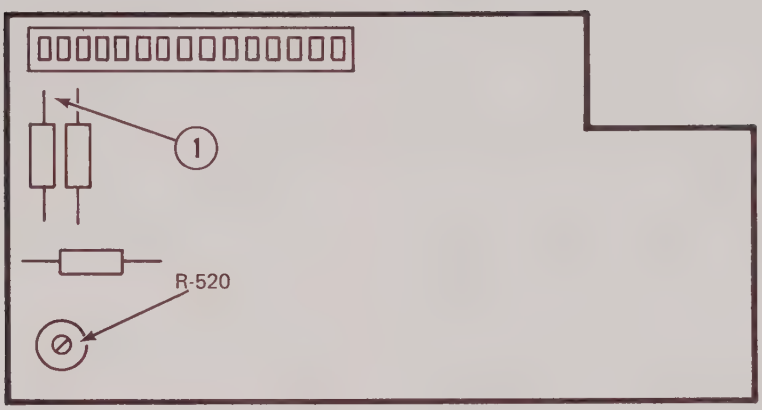


FIGURE 5-4 CALIBRATION TEST POINTS

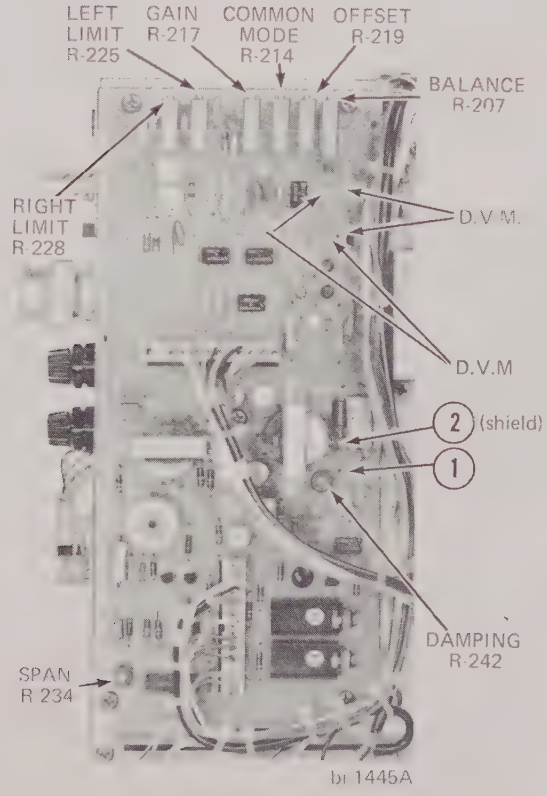


FIGURE 5-5 DRIVE AMPLIFIER CALIBRATION

3. Use POSITION control to set pen to center scale. Voltmeter should read zero volts.

4. Use POSITION control to place pen at either chart edge. Adjust span resistor, R-234, for 1 volt (±0.080 volt) with pen at chart edge.

NOTE: Adjusting span resistor will move pen. Reset pen to chart edge for accurate voltmeter reading.

5. Set front panel SENSITIVITY to 100 millivolts/division.

6. Apply 1 Hz square wave of 20 divisions peak amplitude.

7. Adjust damping resistor, R-242, to the point where the overshoot or notch just goes away.

8. Connect two digital voltmeters across resistors R-205 and R-206. Difference between readings must be less than 0.001 volt.

NOTE: Recorder must have been "on" and warmed up for at least 10 minutes. To warm-up recorder without chart running, depress and release chart speed button so that ALL buttons are in the "out" position. Recorder will be on but chart will be off.

9. If difference is greater than 0.001 volt, adjust balance resistor, R-207.

NOTE: Once this resistor is set, it should not require adjustment unless input FET's are replaced. Consequently, this resistor is sealed at the factory.

10. Replace metal shield using four phillips-head screws.

NOTE: Depress 1 MM/SEC chart speed pushbutton.

11. Adjust offset resistor, R-219, for no pen deflection while varying variable SENSITIVITY X1 control throughout its range.

12. Turn POSITION control fully counterclockwise (to stop) and adjust left limit resistor, R-225, to bring pen 1½ to 2 divisions beyond chart edge.

13. Turn POSITION control fully clockwise (to stop) and adjust right limit resistor, R-228, to bring pen 1½ to 2 divisions beyond chart edge.

14. Set SENSITIVITY control to 1 mv/division and adjust POSITION control on right chart edge.

NOTE: Be sure vernier SENSITIVITY X1 control is in detent position.

15. Apply +50 mv d-c signal to input terminals and adjust gain resistor, R-217, for exactly 50 divisions deflection.

16. Place shorting strap between "+" and "—" input terminals.

17. Connect lead between rear panel case ground terminal and front panel "GD" (guard) terminal.

18. Set SENSITIVITY control to 1 mv/division and apply a 4 volt rms 60 Hz signal between gd (guard) and "—" input terminal. Observed signal should be 1 mv or less. If not, adjust CMR resistor, R-214 for minimum signal.

NOTE: If CMR resistor is adjusted, repeat offset adjustment, step 11.

19. Disconnect all test equipment and assemble recorder. Unit is ready for use.

SECTION VI

THEORY OF OPERATION

6.1 GENERAL

The Brush 222 Recorder consists of two analog channels, associated attenuator controls, penmotor drive amplifiers and power supplies. The recorder also contains built-in battery charging circuits to maintain internal batteries at full charge.

Penmotor drive amplifier is a complete servo system utilizing a Metrisite transducer in the penmotor to develop position feedback and a tachometer generator to derive velocity. Refer to Block Diagram, Figure 6-1.

6.2 DRIVE AMPLIFIER ASM, 882432 (Figure 6-2)

The d-c amplifier input circuitry consists of a balanced, matched FET pair feeding a true differential amplifier made up of operational amplifiers, U-201 and U-202. The current thru each FET is made equal by adjusting resistor R-207 for exactly equal voltages across resistors R-205 and R-206. The output of the differential operational amplifier pair is 25 times the difference between the input signals at terminal 2 and 3 of amplifier U-201.

Resistor R-214, in the feedback circuit, is adjusted for maximum preamplifier gain balance.

Resistor R-217 is the gain adjust resistor and is in series with the 150K ohm front panel vernier sensitivity control. When this sensitivity control is in X1 position, only resistors R-217 and R-218 are between operational amplifier U-202 and limiter operational amplifier U-203.

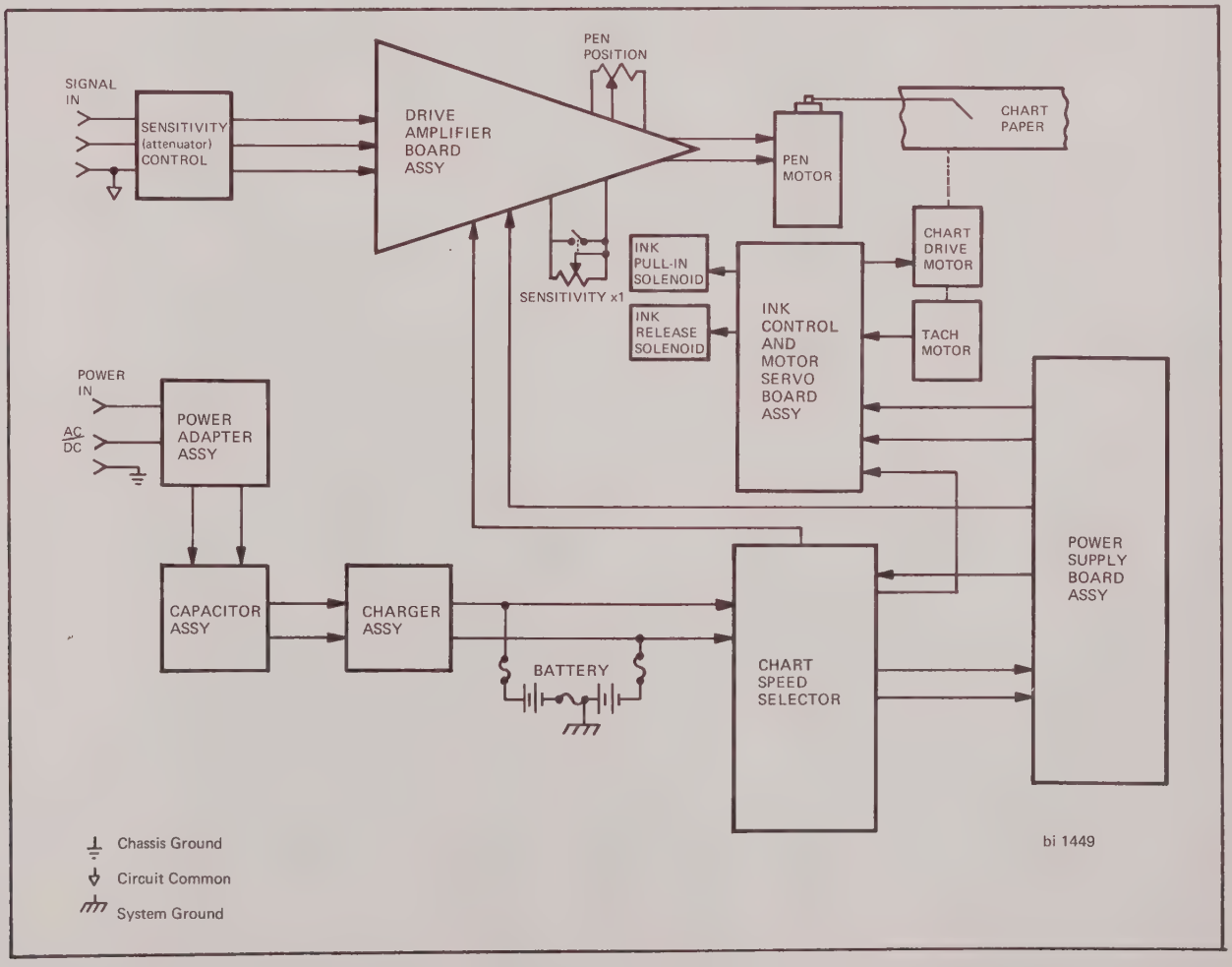


FIGURE 6-1 BRUSH 222 RECORDER – BLOCK DIAGRAM

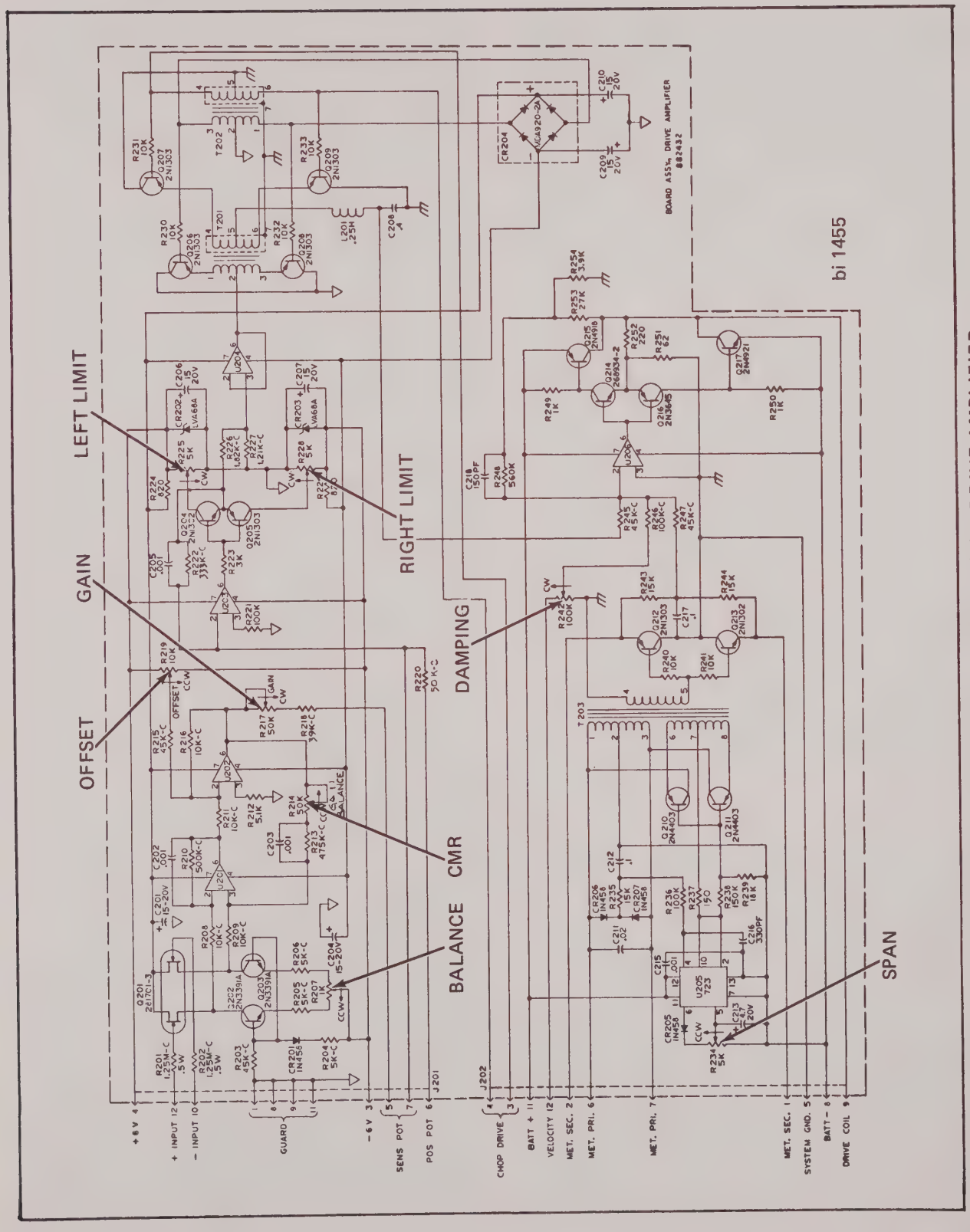


FIGURE 6-2 THEORY OF OPERATION – DRIVE AMPLIFIER

Amplifier U-203 and transistors Q-204 and Q-205 are in the signal limiter stage. This signal limiter combination also has gain. At the emitters of transistors Q-204 and Q-205, there is a total gain of 120. However, this is divided by 2/5 when the signal goes thru resistor-divider combination R-226 and R-227 leaving a gain of 48 at the input or output of amplifier U-204 which is a voltage follower for the purpose of driving the modulator transformer T-201. Resistors R-225 and R-228 adjust the level at which limiting will occur by setting the voltage at the collectors or the point at which they will saturate. The feedback provided by parallel resistor-capacitor combination C-205—R-225 eliminates crossover distortion. Transistors Q-204 and Q-205 are germanium switching transistors further lessening the crossover problem. Diodes CR-202 and CR-203 are special sharp knee zener diodes which will regulate down to two or three hundred micro amps and develop regulated ±6 volts. These zeners were used in order to save battery current. As can be seen, a number of stages receive this regulated ±6 volts. They are as follows: The limiting voltage fed to resistors R-225 and R-228, limiter operational amplifier U-203, differential stage offset resistor R-219 and FET current source bias network, resistor R-204 and diode CR-201. This voltage also feeds the front panel pen position control, R-302. The output of this control is summed with the signal in the inverting input of operational amplifier U-203 providing pen position.

Signal fed to terminal 2 of transformer T-201 is applied to each half at a 3 KHz rate by the alternate switching action of transistors Q-206 and Q-208, resulting in a modulated signal on the secondary of transformer T-201. Demodulated signal appears at terminal 5 of transformer T-201 as a result of synchronous switching action of transistors, Q-207 and Q-209, shorting terminal 4 or terminal 6 to system ground ( ). The secondary of transformer T-202 is driven from a 3 KHz square wave signal called chop drive which comes from the power supply. The secondary of transformer T-202 is used to drive the modulator transistors, Q-206 and Q-208. These are at guard potential and need a winding for isolation; however, the demodulator transistors do not require such isolation, and so are driven right from the chop drive, which enters the drive amplifier board through terminals 3 and 4. The switching transients and ripple are filtered by L-C combination, inductor L-201 and capacitor C-208 to provide a ripple-free signal at summing resistor R-245. Transformer T-202 secondary voltage is rectified by bridge rectifier CR-204 and filtered by capacitors C-209 and C-210 to provide ±15 volts d-c which is isolated from system ground.

The drive amplifier, made up of operational amplifier U-206 and transistors Q-214, Q-215, Q-216, and Q-217, acts as a summing and error amplifier. The signal at resistor R-245 is constantly compared with the pen position at resistor R-247 and assures that the pen accurately displays the signal on the chart. The tachometer within the penmotor generates a pulse whose amplitude is proportional to velocity and whose polarity is dependant on the direction the pen is moving. By summing this signal into the pen position signal at resistor R-247 and the input signal at resistor R-245, ideal square wave response may be obtained by critical adjustment of damping resistor R-242.

Q-210 and Q-211 are oscillator transistors, driving cup-core transformer T-203. Winding 1-3 provides feedback to sustain oscillation. It also provides sufficient 20KHz sine wave voltage to drive the primary of the position sensing transducer (Metrisite) which is within the penmotor assembly. Operational amplifier U-205 regulates the amplitude of the 20KHz position sensor drive voltage. Metrisite primary voltage is rectified by diodes CR-206 and CR-207, filtered by capacitor C-212 and compared with an internal temperature compensated d-c reference in operational amplifier U-205. Voltages at terminal 10 of operational amplifier U-205 correspond to corrections needed in the amplitude of the position sensor (Metrisite) drive voltage in order to keep the position signal true. Resistors R-238 and R-239 form a bias network for the oscillator transistors. Resistor R-234 controls the amount of d-c fed to the oscillator and thereby controls the amplitude of the 20KHz Metrisite drive. This control is used to initially set up span, i.e., ±1 volt out of the demodulator for ±25 divisions of pen displacement.

Transistors Q-212 and Q-213 form a complementary demodulator pair alternately switching ends of the metrisite secondary to system ground at a 20 KHz rate. The voltage at the emitters is summed thru resistors R-243 and R-244 and filtered with capacitor C-217 to provide d-c position feedback voltage to be summed with the signal voltage at terminal 2 of operational amplifier U-206. The error voltage is amplified by operational amplifier U-206 and applied to transistors Q-214 and Q-216, which form a phase splitting driver for the output power transistors Q-215 and Q-217. Resistor divider network R-253 and R-254 form part of feedback circuit by dividing the output by 10 and resistor R-248 and capacitor C-218 establish the gain at d-c and provide the proper roll off characteristics for stable operation of the servo loop (Penmotor-Metrisite-Amplifier). The servo loop

gain of 100 is necessary to provide sufficient stiffness (restoration force) and adequate stability during recovery from transients.

6.3 INK CONTROL AND MOTOR SERVO BOARD ASSEMBLY 882427 (Figure 6-3)

The function of this board is to amplify the difference between the speed reference voltage and the d-c tachometer. The difference voltage drives the chart at a selectible, constant speed.

The ink control circuitry turns on the ink when battery voltage is applied and turns the ink off when the "off" button is depressed or, when the paper supply is near the end or, when the battery voltage falls below approximately 10.5 volts.

Resistors R-518 and R-519 are reference voltage and tachometer summing resistors, respectively. Operational amplifier U-501 amplifies the difference between the tachometer voltage and the speed reference voltage. The output at terminal six drives transistors Q-508 and Q-509. Note that operational amplifier U-501, terminal 7, is connected to A^1 which is a voltage 12 volts above battery +. Also, terminal 3, non-inverting input, is referenced to battery +. The tachometer is referenced to battery +, driving negative voltage into resistor R-519. The speed reference voltage power supply is also referenced to battery +. The quiescent output of operational amplifier U-501 will prevent any backward driving voltage from reaching the output transistors. As the signal at pin six goes more negative than 0.6 volts the chart will drive. This is done to ensure that the motor does not drive in the backward direction. The chart drive motor is in the collector circuit of transistor

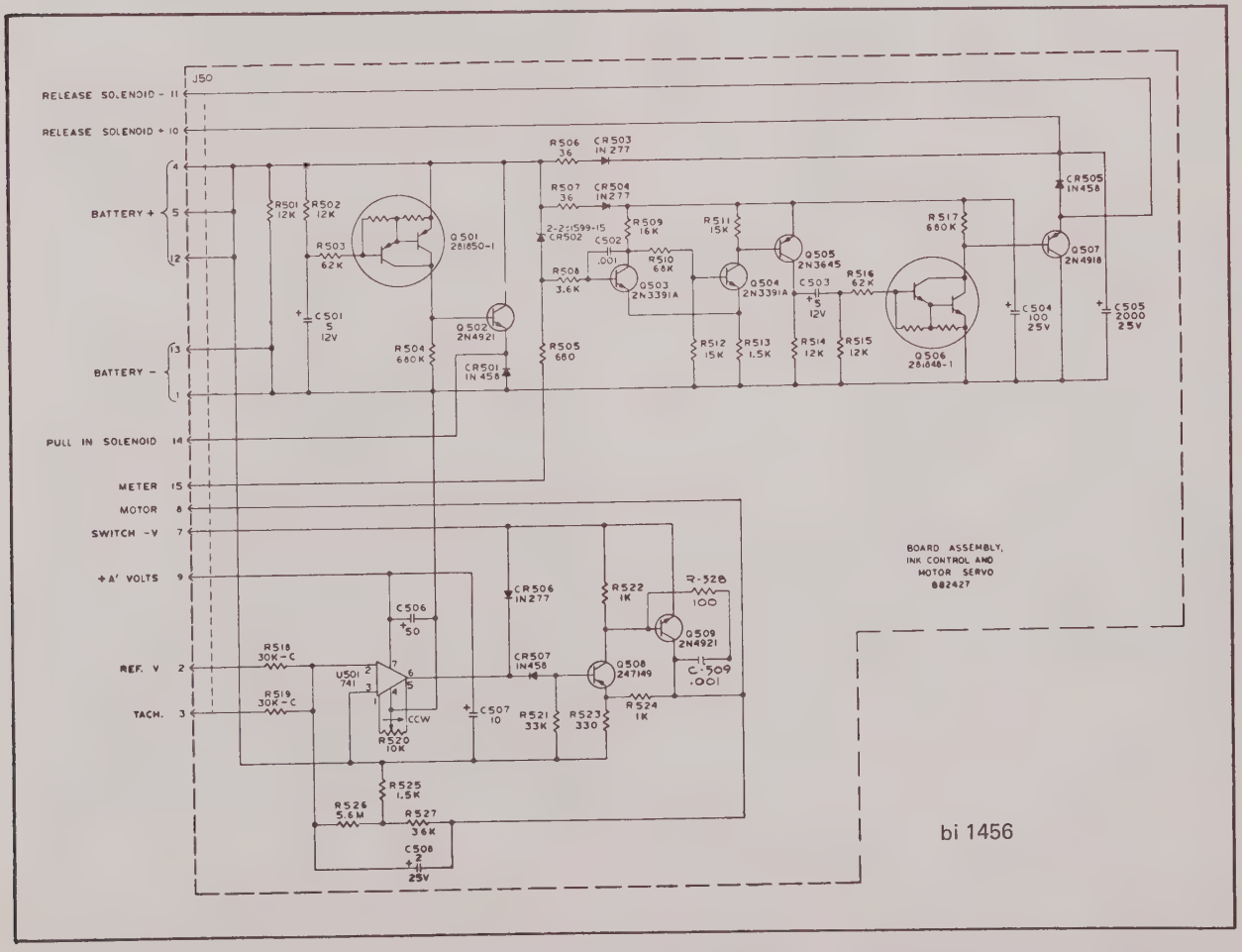


FIGURE 6-3 THEORY OF OPERATION – INK CONTROL AND MOTOR SERVO BOARD

Q-509, driving the servo motor as it is turned on by transistor Q-508. Transistors Q-508 and Q-509 work as a modified emitter follower to give a gain of 4 to the system. Diode CR-506 prevents the forward biasing of the collector base junction of transistor Q-508 which would result in a latching condition. The gain of the servo loop is 5000. RC network consisting of resistors R-525, R-526, and R-527 with capacitor C-508 gives a smooth roll of about 1 Hz.

Resistor R-501, 12K ohms, permits the ink turn-on circuit to be cycled rapidly by bleeding off the charge on capacitor C-501. When voltage is applied to terminals 5 and 13, as when the chart speed buttons are depressed, capacitor C-501 charges momentarily turning transistor Q-501 on, pulling the base of transistor Q-502 up to its collector. This turns transistor Q-502 on for a short time causing the ink solenoid to be energized. Diode CR-501 is across the solenoid as an inductive transient suppressor. Diode CR-502, is a 9.2 volt zener whose current flows thru resistor R-505 and the 0-1 maximum battery condition meter. Diode CR-502, while in avalanche condition (>.3 ma approximately), holds the junction of resistors R-505 and R-508 nine volts below battery positive and approximately three volts above battery negative. Because the base emitter junction of transistor Q-503 is forward biased, transistor Q-503 is in the on condition holding transistor Q-504 "off" by way of resistor R-510. This is the condition for all voltages above approximately 10.5 volts. When diode CR-502, the 9 volt zener, gets close the point of not conducting (0.2 or 0.3 ma) an avalanche effect takes place. Transistor Q-503 turns off and transistor Q-504 is turned on by transistor Q-503's action. The negative swing at collector of transistor Q-504 is amplified and inverted by transistor Q-505. The abrupt positive change at the collector of transistor Q-505 causes capacitor C-503 to charge up, driving current from the emitter up thru the base of transistor Q-506 turning it on for the duration of time it takes to charge capacitor C-503. When the collector of transistor Q-506 drops down toward its emitter this forward biases the base emitter junction of transistor Q-507, a PNP power transistor, causing the energy stored up in capacitor C-505 to flow thru the collector and emitter of transistor Q-507 and out thru the release solenoid, turning the ink off after all circuitry is disconnected from battery power.

6.4 POWER SUPPLY BOARD ASSEMBLY 882429 (Figure 6-4)

Battery voltage is applied to transistors Q-3 and Q-4 of array U-301 causing a square wave to be developed at collectors transistors Q-3 and Q-4, which is amplified by array transistors Q-1 and Q-2. The amplified square wave of sufficiently low source impedance is applied to the bases of power transistors Q-301 and Q-302, causing square wave current to flow alternately in each half of transformer T-301; the total peak-to-peak voltage between terminals 1 and 5 is doubled by the resulting auto-transformer effect. Minus 18 volts, used in the chart drive servo circuitry, is developed from the 3 KHz square wave voltage rectified by diode CR-301 and filtered by capacitor C-301. This negative voltage is used by the servo system at 50 mm/sec. chart speed. The +12 volts, A^1, developed by coupling electrolytic C-306 and voltage doubler CR-302 and filter capacitor C-307, is used to operate the speed reference power supply and the motor servo operational amplifier U-501. An eighty volt peak-to-peak square wave is "chop drive", developed by the 3:1 ratio from the entire primary winding of T-301 to secondary transformer taps no. 10 and no. 8, with no. 9 being the center-tap and system ground ( ). Transformer taps no. 6 and no. 7 develop a square wave which is rectified by diode CR-303 and filtered by capacitor C-308. This voltage is used to power the servo amplifier output stage in chart speeds 1, 2, 5 and 10 mm/sec. This voltage, like + A^1, is developed with respect to the +12 volt battery. Precision d-c speed reference voltages are developed by voltage regulator U-302 and resistor-divider network R-316 thru R-326. (R-313 is adjusted so that the voltage at terminal 3 is exactly 5.000 volts). These voltages are brought up to the chart speed selector pushbuttons. Operational amplifier U-303 amplifies the pushbutton selected d-c reference voltage. The gain of this amplifier is adjusted to calibrate the chart speed at 10 mm/second. R-329 is adjusted to obtain zero volts out with the input shorted, as when a shorted phone plug is plugged into the rear external d-c chart drive jack.

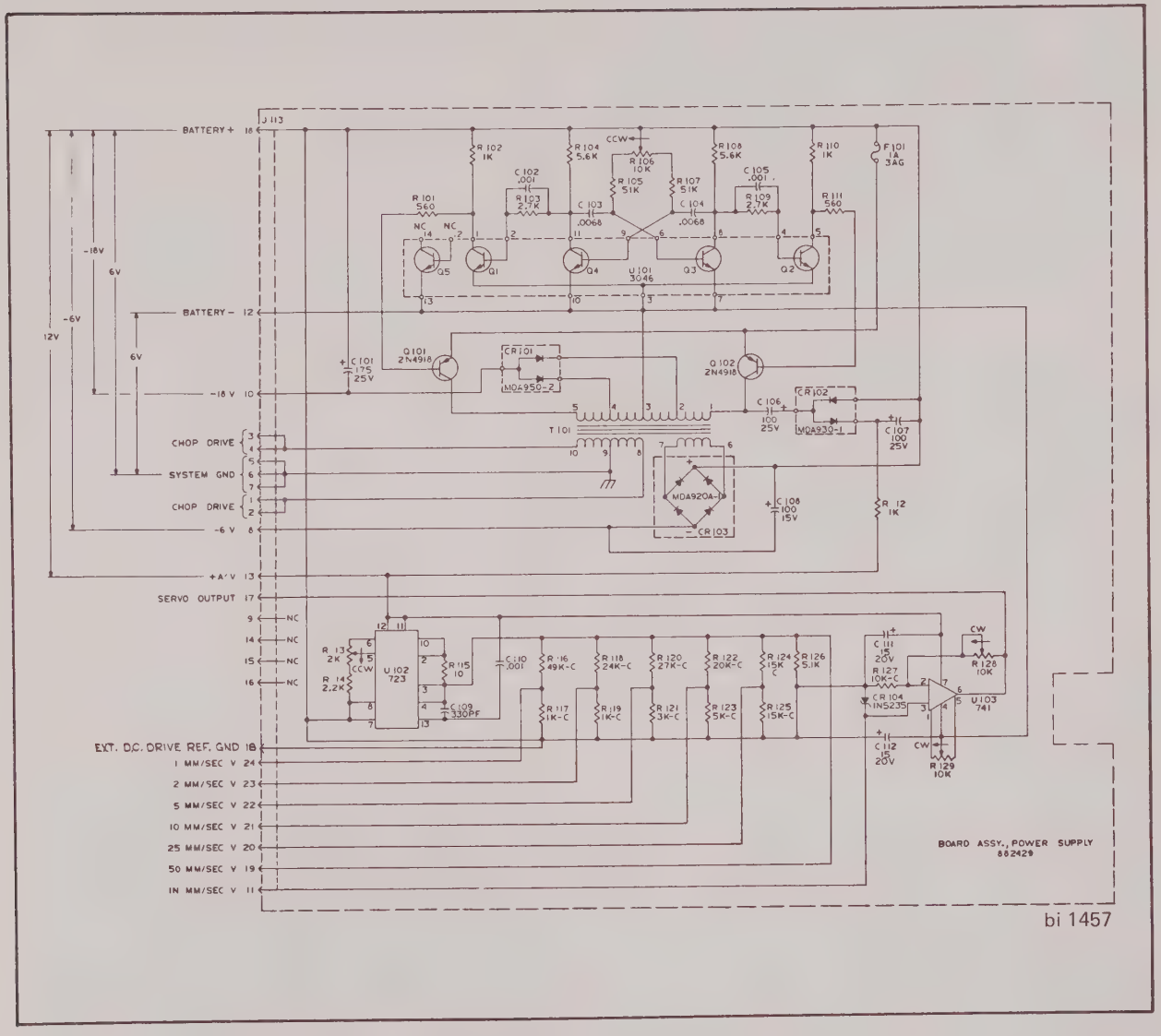


FIGURE 6-4 THEORY OF OPERATION — POWER SUPPLY BOARD

6.5 CAPACITOR BOARD ASSEMBLY, 782423 (Figure 6-5)

This printed circuit board has rectifier diodes CR-601 and CR-602, which are used in the charger circuit. This board also has the filter capacitors used with the rectifier diodes. Access to the diodes alone and the electrolytics by themselves permits various hookup combinations to be achieved by plugging in one of the three different charger power adapter modules.

6.6 POWER ADAPTERS (782233, 782235, 782237) AND CHARGER ASSEMBLY 782425 (Figure 6-6)

Printed circuit cards inserted into the rear card edge connector of the 222 apply 115, 230 a-c or 12-33 volts d-c to the charger circuitry.

When the 115V a-c adapter card is plugged in and 115 volts is applied to it the primaries of the

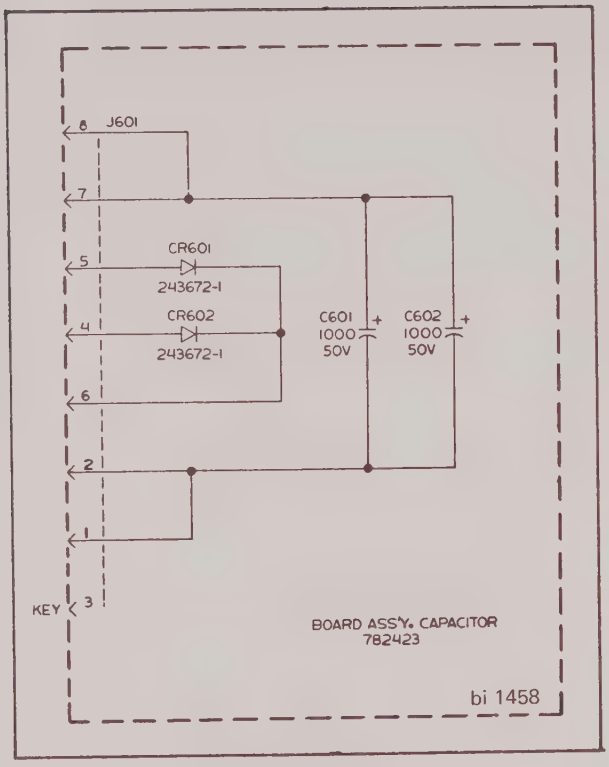


FIGURE 6-5 CAPACITOR BOARD

charger transformer are in parallel and in phase. The secondary along with CR-601 and CR-602 alone with its centertap form a full wave rectifier circuit. The circuitry on the adapter card connects terminal six of the capacitor board assembly to terminal seven of this same assembly (see pages 5 and 6 of schematic 282442). C-601 and C-602 filter the full wave rectified voltage which leaves this board via terminal 7 and is applied to terminal 3 of J-401, charger assembly. Terminal 2 and 3 of J-801 are connected together in the case of the 115V a-c adapter plug-in (see page 6 of 6 of schematic 282442) thereby connecting T-301 center tap to the capacitor board assembly termial 1. Terminal 1 is connected to terminal 2 of J-601, capacitor board assembly (see page 5 of 6 of 282442). Terminal 2 is connected to the charger assembly which is shown on page 5 of schematic 282442. Terminal 8 is center tap of the charger transformer or common point. Terminal three is the + input terminal of the charger board assembly. The jumper between terminal 3 and terminal 4 applies + d-c (12-33 volts) to the emitter of the power transistor Q-301 which is shown on page 1 of schematic 282442. Transistor Q-301 is the series pass transistor of the constant voltage current limited charger circuit charger board assembly 782425. Terminal 5 of J-401 connects the base of Q-301 to the charger card. Terminal 2 connects the collector of Q-301 to the charger card. Q-301 is mounted on the left hand side plate for increased heat dissipation. Terminal 2, charger output voltage, is connected to terminal 1 of J-401 by way of CR-401, a germanium diode (1N91), to keep the voltage comparator divider resistors R-403 and R-407 and gain setting resistors R-402 and R-406 from the battery during periods when the unit is not being charged. The heart of the charger circuit is a Fairchild 723 precision voltage regulator. This circuit was devised so that as little voltage as possible would be lost from input to output. The input-output differential is only 0.5 volt.

Resistors R-403 and R-407 form a resistor divider string whose mid point derives a voltage of 6.31 volts, very near to the temperature compensated internal voltage reference of the 723. This voltage is applied to terminal 4 (inverting input) of the 723 regulator. The internal reference voltage from terminal 6 is applied to potentiometer R-404 and wiper swing limiter resistor R-405, the end of which is tied to V— or common, terminal 7. The voltage applied to terminal 5 is set by resistor R-404 and controls the output voltage of the regulator chip which is at terminal 10. If the charger is set at 13.9 volts the voltage at terminal 10 must be 6.9 volts or one half of the charger output voltage. The 723 operates at 6.9 volts but keeps the collector of the power transistor Q-301 at 13.9 volts except when current limiting. Transistor Q-301 is driven from the collector of transistor Q-15, (which is inside the 723 regulator) causing the output voltage of the charger to be twice the voltage which is at the midpoint of the resistor R-402—R-406 divider string. Transistor Q-15 is an emitter follower driven by transistor Q-14, which is driven from the voltage comparitor, transistors Q-11,Q-12. Transistors Q-301, Q-14 and Q-15 form a gain of 2 amplifier. Maintaining a 3 volt differential between terminal 12 and terminal 10 permits going down to 1/2 volt between emitter and collector of transistor Q-301. The regulator is operating at a level 6 volts lower than the V+ (terminal 12) keeping transistors Q-11, Q-12 and Q-8 from starving, current wise. The value of resistor R-408 was selected to shut down the regulator at 850 ma, as in the case of batteries which require charging.

When the d-c adapter plug-in is used the circuitry on the plug-in printed circuit card puts the external d-c across the filter capacitors C-601 and C-602 and also applies it to the regulator circuitry.

When the 230 volts a-c plug-in is used a-c is applied to the two primaries in series. This is accomplished by the printed circuit configuration on the card switching the ends of the transformer from parallel (115V a-c) to series (230V a-c).

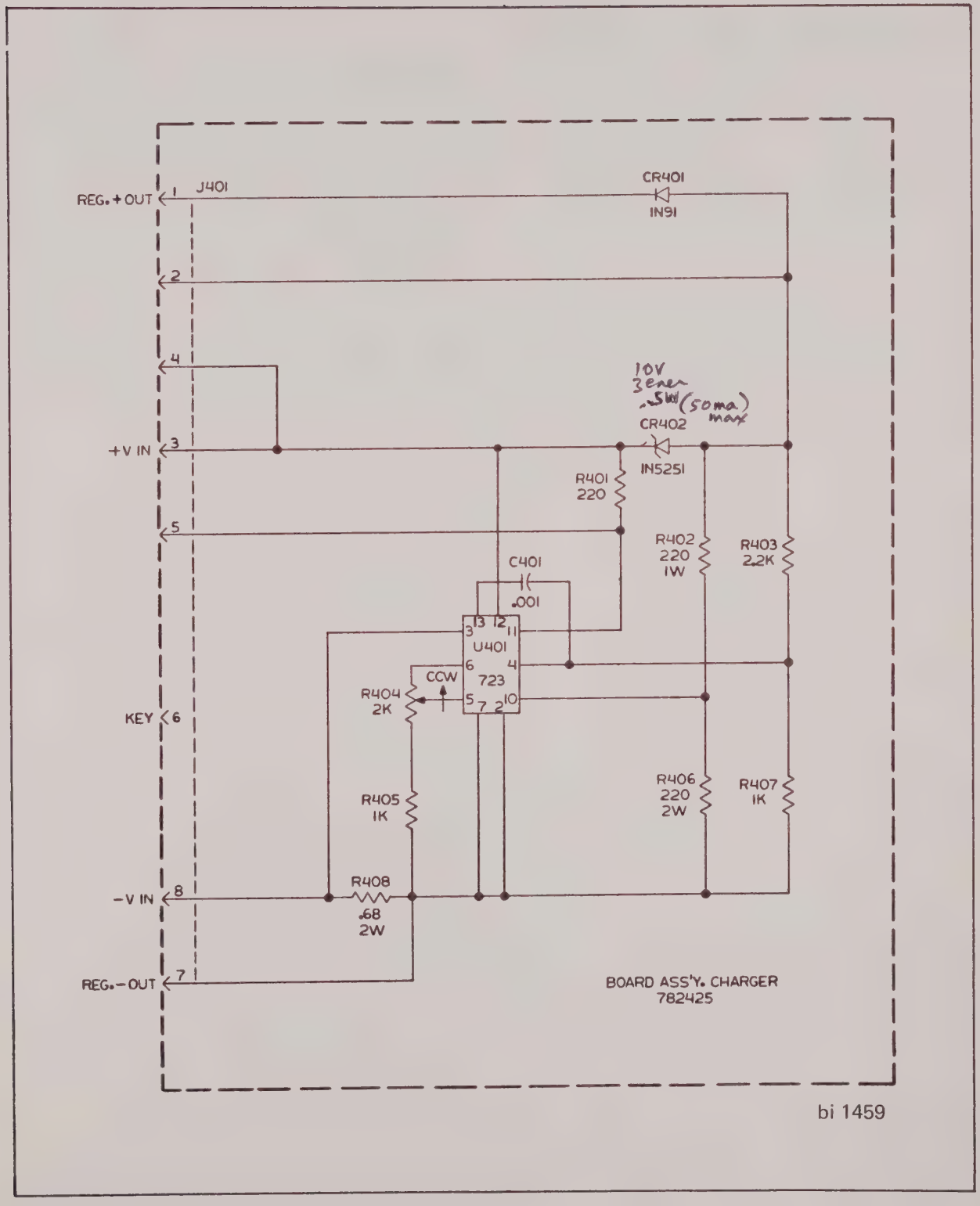


FIGURE 6-6 THEORY OF OPERATION – CHARGER BOARD

SECTION VII

PARTS IDENTIFICATION

7.1 GENERAL

This recorder has been accurately calibrated and adjusted before shipment from the factory and should give long, trouble-free service. For servicing beyond the scope of the instructions contained in this manual or the technical equipment available, contract your nearest Brush Service Engineer listed on the warranty card shipped with the recorder.

The following parts lists and schematic diagrams are designed to assist in servicing and repairing the recorder.

NOTE: Check to be sure the schematic number and revision letter stamped on the rear of the recorder agree with the number and revision letter on the schematic contained in this section.

To assure prompt and satisfactory delivery of replacement parts, include the following with the purchase order.

1. Name, model number, and serial number of the instrument.

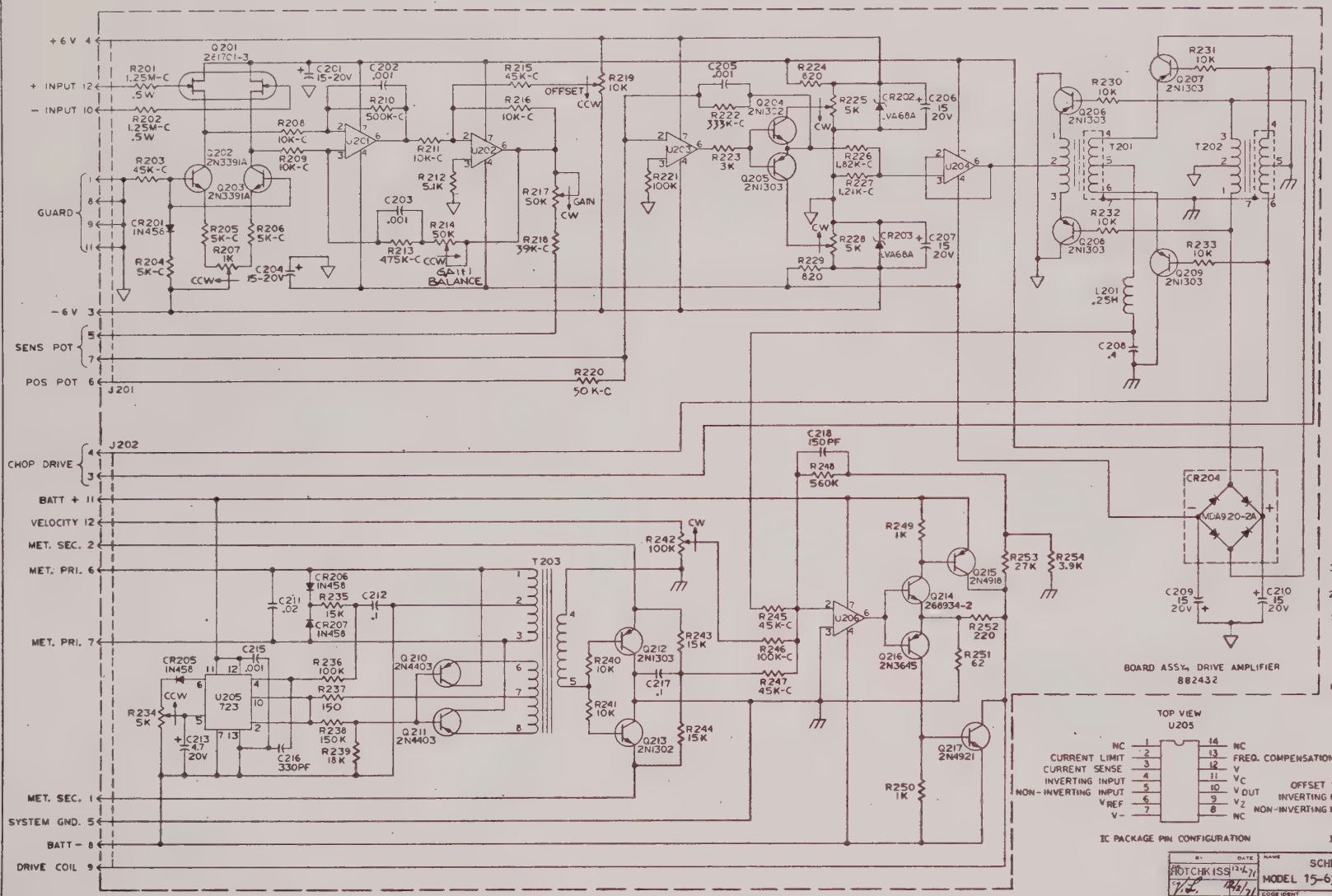
   For Example: Brush 222 Recorder, Model 15-6325-00, Serial Number _____

2. Description of the part as listed in the manual.

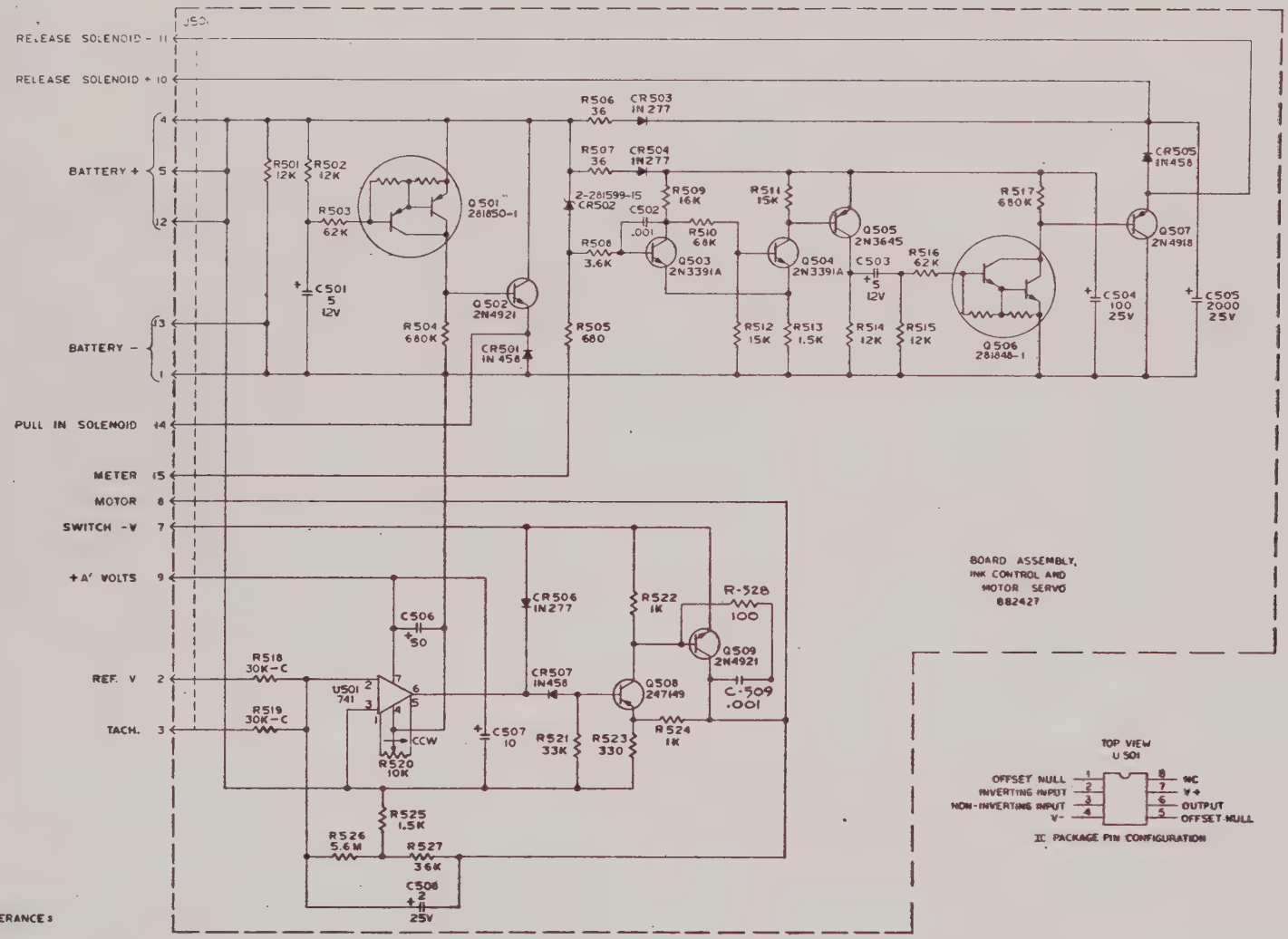
3. Brush part number.

NOTE: Do not use the SYMBOL NUMBER from the parts list for identifying desired parts on the order.

REV. E-1
S701 SWITCH ASSY. 881956
POWER ADAPTER ASSY.
15-6325-00 (115 V) 782235
15-6325-01 (230 V) 782233
15-6325-02 (12/33V) 782237
(SEE PG.6)
P201 J201 J202 P202
BOARD ASSY. DRIVE AMPLIFIER 882432
(SEE PG. 2)
PENMOTOR ASSY 881908
P313-2 (CH 1)
P313-1 (CH 2)
P313-4 (CH 1)
P313-3 (CH 2)
POLARIZATION KEY
+6V
-6V
CHASSIS GND.
T301 CHARGER XFMR
J315
EXT. D.C. POWER OUTPUT
P113 J113
P202-4 (CH 1)
P202-3 (CH 1)
P202-4 (CH 2)
P202-3 (CH 2)
BOARD ASSY. POWER SUPPLY 882429
(SEE PG. 4)
BOARD ASSY. CAPACITOR 782423
(SEE PG. 5)
BOARD ASSY. CHARGER 782425
(SEE PG. 5)
P601 J601
P401 J401
1 MV
2 MV
5 MV
10 MV
20 MV
50 MV
100 MV
200 MV
500 MV
1 V
2 V
5 V
10 V
OFF
R714 2.5M-D
R715 1.5M-D
R716 500K-D
R717 250K-D
R718 150K-D
R719 50K-D
R720 25K-D
R721 15K-D
R722 5K-D
R723 2.5K-D
R724 1.5K-D
R725 500-D
R726 500-D
R701 2.5M-D
R702 1.5M-D
R703 500K-D
R704 250K-D
R705 150K-D
R706 50K-D
R707 25K-D
R708 15K-D
R709 5K-D
R710 2.5K-D
R711 1.5K-D
R712 500-D
R713 500-D
.5W
S301 SENSITIVITY
R301 150K
CW
POSITION
R302 5K
POLARIZATION KEY
NC
L301 RELEASE SOL
E.M.(LH) 11-2123-33
E.M.(RH) 11-2123-34
(OPTIONAL) E.M.(CENTER) 11-6221-01
(OPTIONAL) TIMER (1 SEC.) 11-6101-41
J314 P314 KEY
TB301
TB302
S302
S303
C301 .22
C302 .22
C303 .22
J308 J309
J304 J305 J306 J307
(OPTIONAL) TIMER (1 SEC.) 11-6101-41
CR301 IN2069
S306 TIMER (OPTIONAL)
OFF
ON
BT301
BT302
P311 J311
P310 J310
POLARIZATION KEY
F301 3A SLO-BLO
F303 8A
F302 3A SLO-BLO
Q301 2N3612
BOARD ASSY INK CONTROL AND MOTOR SERVO 882427
(SEE PG. 3)
J501 P501
47/20
C-303
B301 MOTOR, TACH
B302 CHART DRIVE MOTOR
L302 PULL-IN SOL.
POLARIZATION KEY
M301 0-1 MA
BATTERY CONDITION
R303 2.2K
END OF CHART S304
NC NO NC NO
10/20
C-304
10/20
C-305
CR302 IN2069
-12V
S305 CHART SPEED (MM PER SEC.)
OFF 1 2 5 10 25 50
J312
EXT. D.C. CHART DRIVE INPUT
NOTES:
1. UNLESS OTHERWISE INDICATED:
ALL CAPACITANCE IN MICROFARADS.
ALL RESISTANCE IN OHMS.
ALL RESISTORS 1/4W. 5%.
ALL VOLTAGES REFERENCED TO SYSTEM GROUND.
2. IS SYSTEM GND. (NOT CASE OR CHASSIS GND.)
3. EIA COLOR CODE.
4. RESISTOR TOLERANCE: D=.50%.
5. * CHANNEL ONE TYP. OF TWO CHANNELS.
RECORDER
BY DATE NAME
ROTCHKISS 12-1-71
SCHEMATIC
MODEL 15-6325-00,-01,-02
Gould Inc. Instrument Systems Division Cleveland Ohio 44114 USA
CODE IDENT 96795
SIZE D
DWG NO 282442
PAGE 1 OF 6



BY / DATE	NAME		Gould Inc Instrument Systems Division Cleveland, Ohio 44125 U.S.A.
HOTCHKISS 12-2-71	SCHEMATIC MODEL 15-6325-00,-01,02		
P.L. 12/6/71	CODE IDENT 96795	SIZE C	DWG NO 282442
P. McCabe 12-3-71			PAGE 2 OF 6



BOARD ASSEMBLY,
INK CONTROL AND
MOTOR SERVO
882427

TOP VIEW
U 501

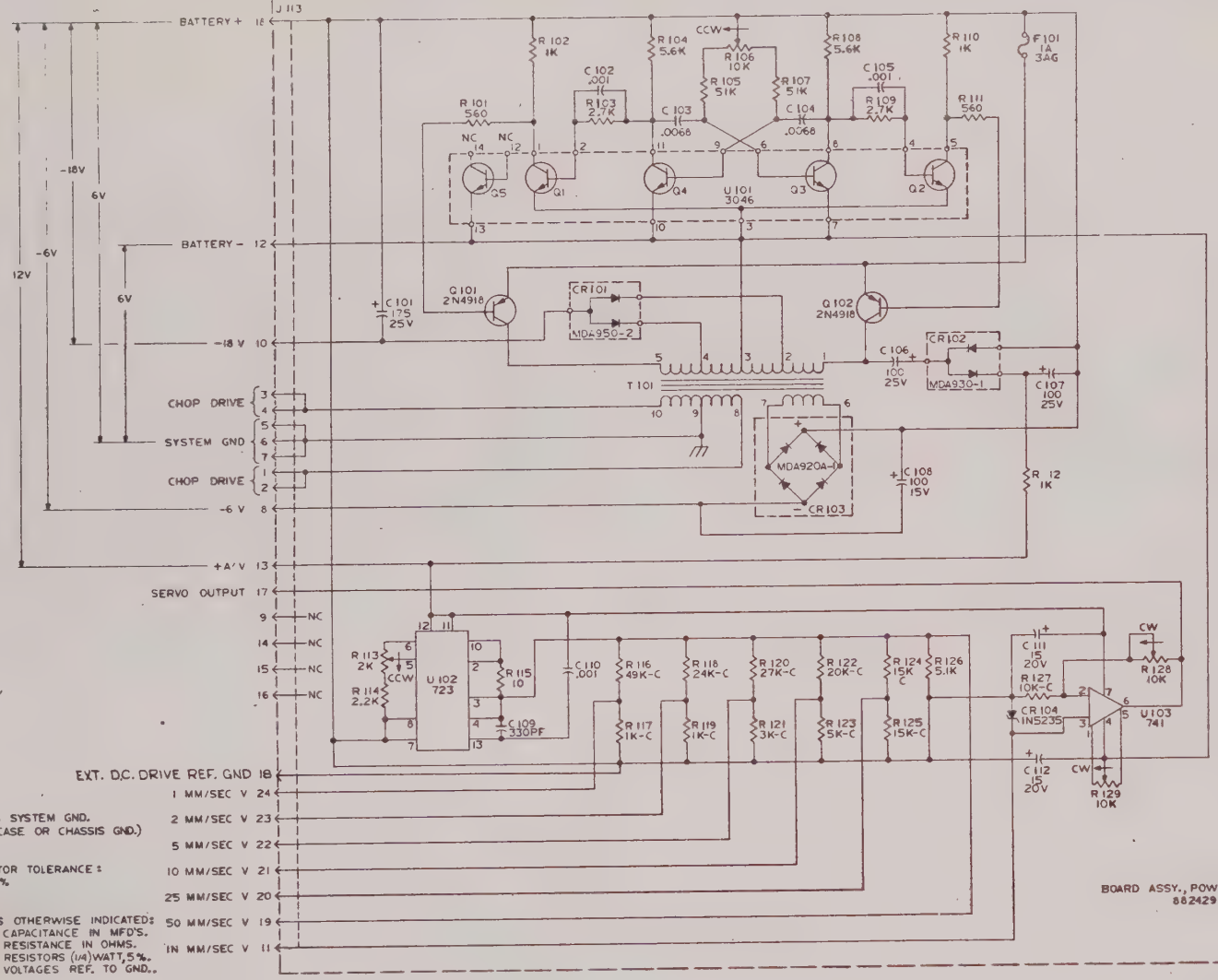
IC PACKAGE PIN CONFIGURATION

2. RESISTOR TOLERANCE:
C=.25%

UNLESS OTHERWISE INDICATED:
ALL CAPACITANCE IN MICROFARADS.
ALL RESISTANCE IN OHMS.
ALL RESISTORS (1/4) WATT, 5%.
ALL VOLTAGES REFERENCED TO GROUND.

NOTES:

BY	DATE	NAME	SCHEMATIC	Gould Inc. Instrument Systems Division Cleveland, Ohio 44114 U.S.A.
HOTCHKISS	12-1-71	MODEL	15-6325-00,-01,02	
J.F.	12/6/71	CODE IDENT	96795 SCALE G	DWG NO 282442
Psmc	12-3-71			PAGE 3 OF 6



TOP VIEW
U 302

NC	1	14	NC
CURRENT LIMIT	2	13	FREQ. COMPENSATION
CURRENT SENSE	3	12	V+
INVERTING INPUT	4	11	VC
NON-INVERTING INPUT	5	10	V OUT
VREF	6	9	VZ
V-	7	8	NC

IC PACKAGE PIN CONFIGURATION

3. ⏚ IS SYSTEM GND. (NOT CASE OR CHASSIS GND.)

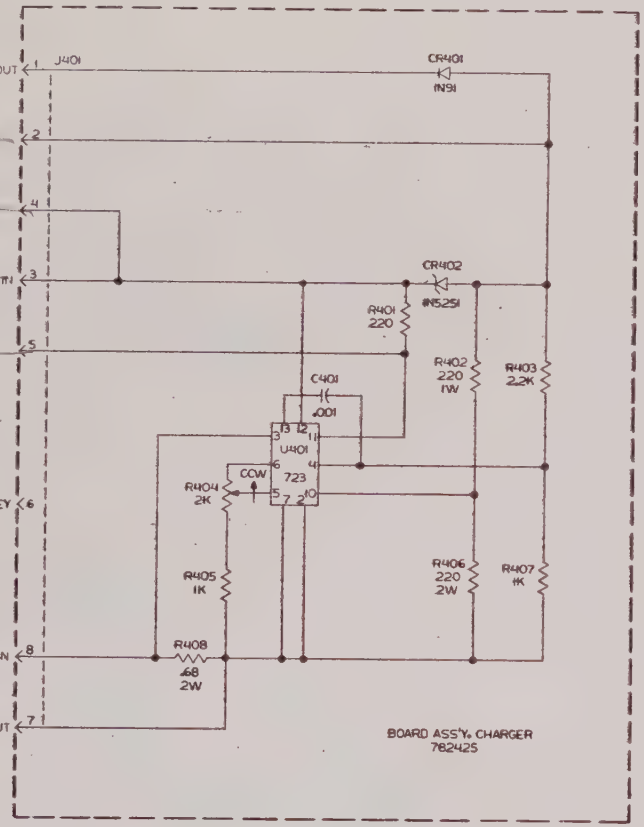
2. RESISTOR TOLERANCE ± C=.25%

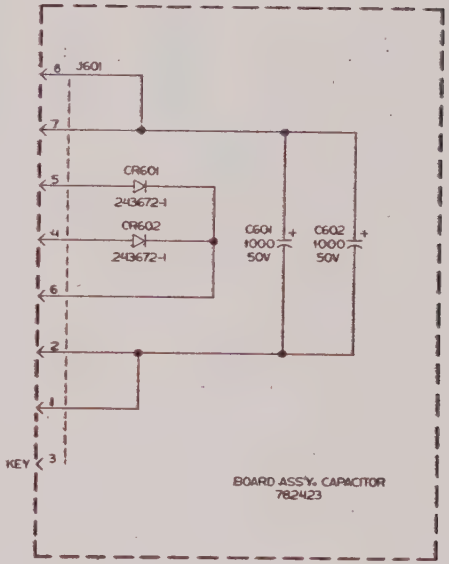
1. UNLESS OTHERWISE INDICATED: ALL CAPACITANCE IN MFD'S. ALL RESISTANCE IN OHMS. ALL RESISTORS (1/4) WATT, 5%. ALL VOLTAGES REF. TO GND.

NOTES:

BOARD ASSY., POWER SUPPLY
882429

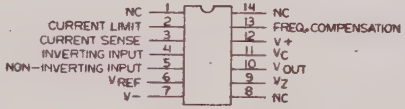
DR NOTCH ISS	DATE 12-1-71	NAME SCHEMATIC	Gould Inc Instrument Systems Division Cleveland Ohio 44114 U.S.A.	
CH J.L.	12/3/71	MODEL 15-6325-00,-01,02		
APP BMC	12-3-71	CODE IDENT 96795	SIZE D	DRAWING 282442
				PAGE 4 OF 6





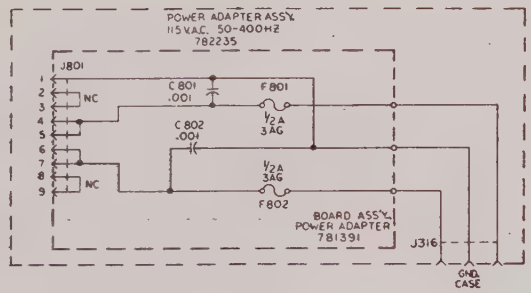
NOTES:
1. UNLESS OTHERWISE INDICATED:
   ALL CAPACITANCE IN MICROFARADS.
   ALL RESISTANCE IN OHMS.
   ALL RESISTORS 1/4 WATT 5%.
   ALL VOLTAGES REFERENCED TO GROUND.

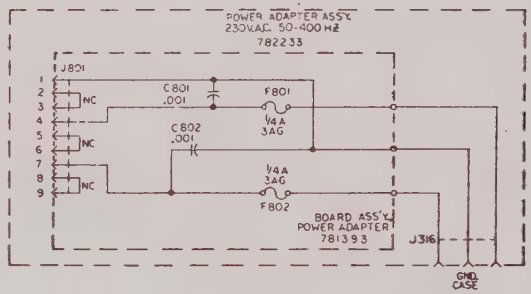
TOP VIEW
U401

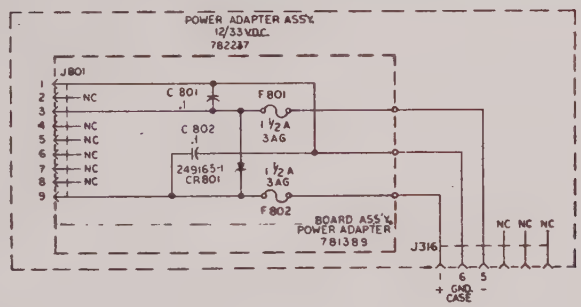


IC PACKAGE PIN CONFIGURATION

BY	DATE	NAME	SCHEMATIC	Gould Inc. Instrument Systems Division Cleveland Ohio 44114 U.S.A.
HOTCHKISS	12/1/71	MODEL	15-6325-00, -01, 02	
	12/3/71	CODE IDENT	96795	DRG. NO. 282442
		SIZE	G	PAGE 5 OF 6

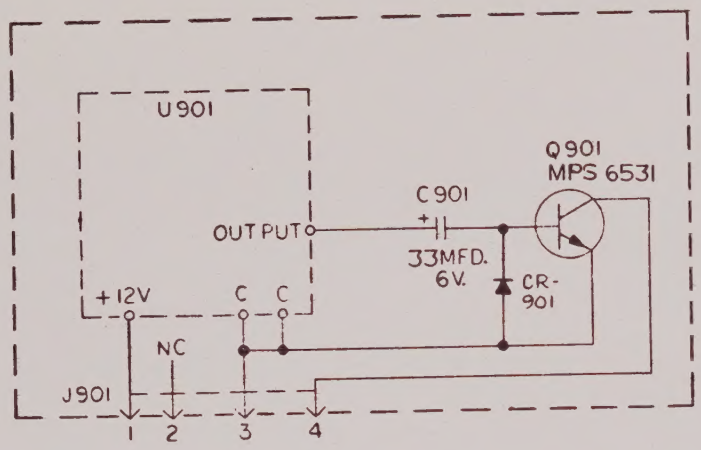






BY HOTCHKISS	DATE 12-1-71	NAME SCHEMATIC MODEL 15-6325-00,-01,02	Gould Inc. Instrument Systems Division Cleveland Ohio 44114 USA	
CHK'D PSyme	12-3-71	CODE IDENT 96795	SIZE CODE G	DWG NO 282442 PAGE 6 OF 6

REVISIONS			
SYM	DESCRIPTION		APPROVED
A-1	Q-901 WAS: 2423283 DCN 16658 LK		5-18-72
A-2	C-901 WAS: 10MFD/20V RE-ISSUE OF DCN 16658		K. SAYLER 5-23-72
B-1	ADDED CR-901 PER DCN 16945		VAUGHN 9-28-72



1 SEC. TIMER ASSY.

BY JORDAK	DATE 11-3-71	SCHEMATIC MODEL NO. 11-6101-11	Gould Inc Instrument Systems Division
CHK	1-5-72	CODE IDENT 96735	SIZE G
APP	1-5-72		DWG NO. 281939

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3631 Perkins Avenue, Cleveland, Ohio 44114
Telephone (216) 361-3315

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